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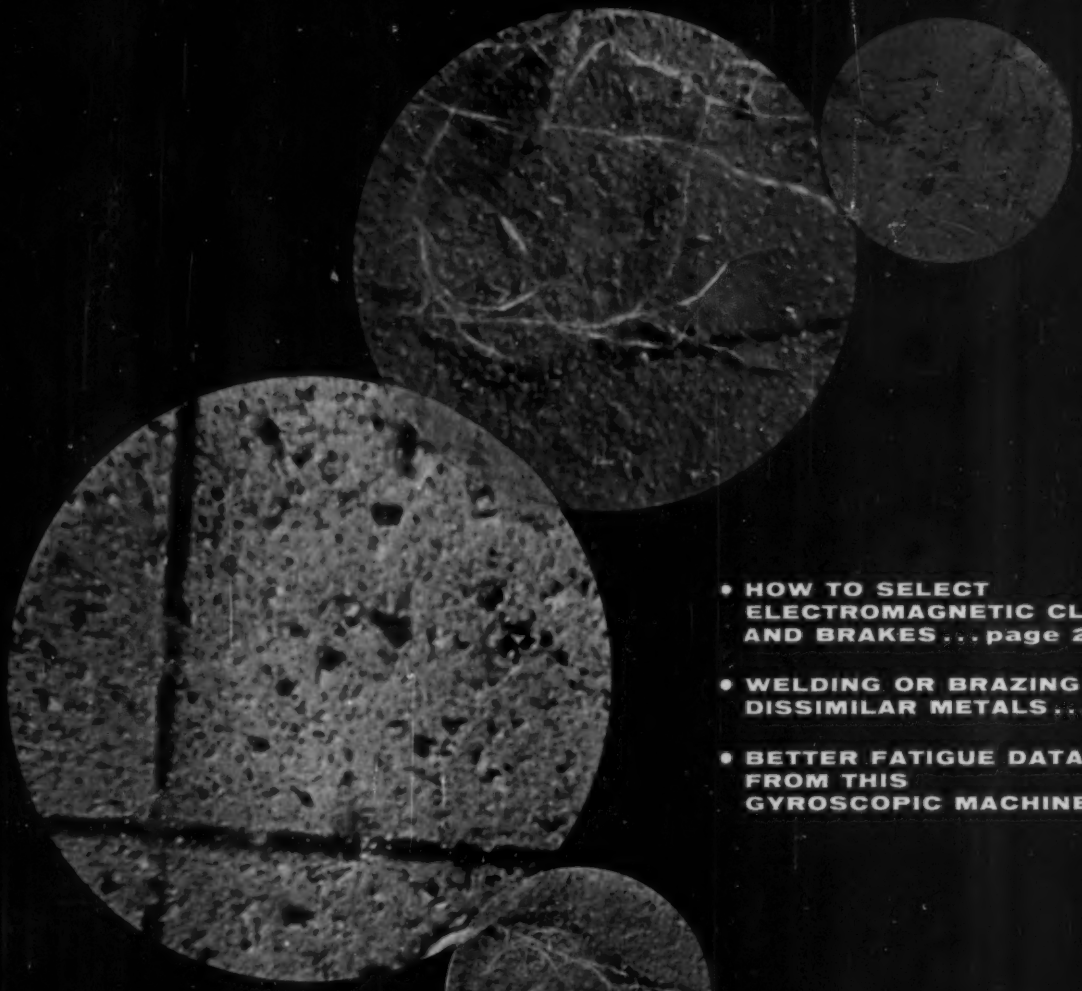
McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS • DECEMBER 19, 1960



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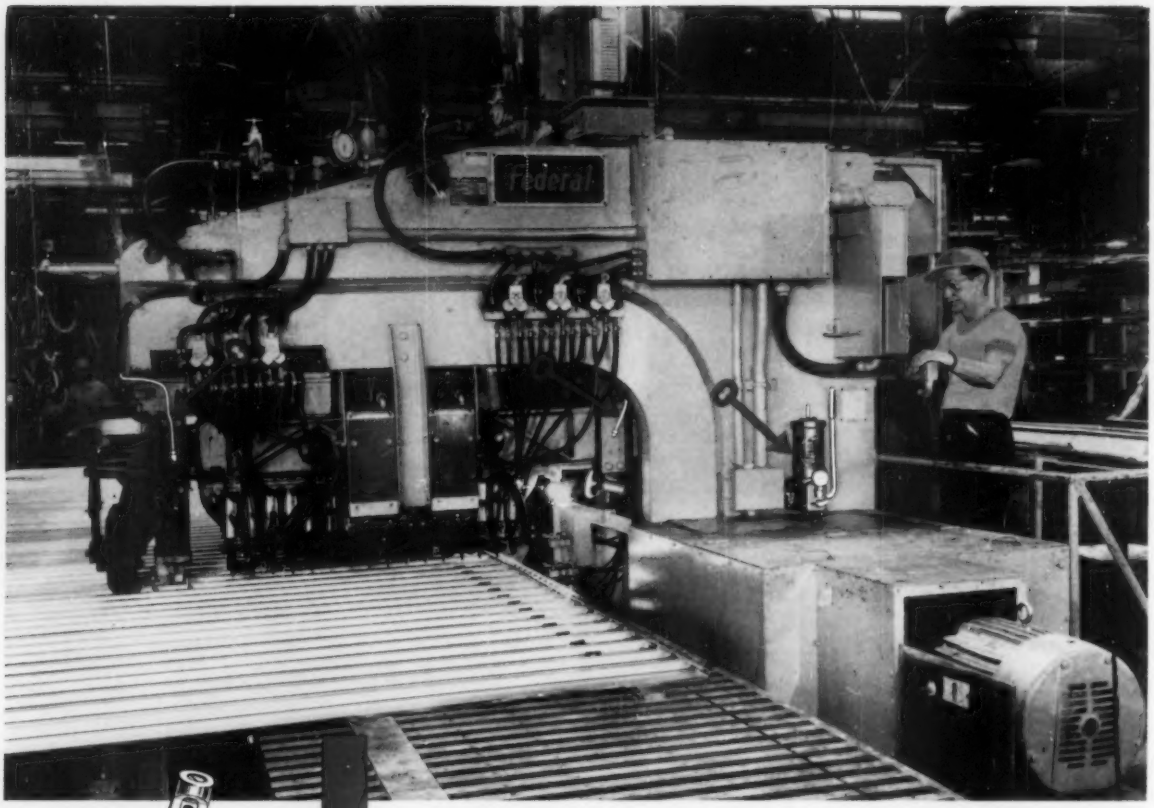

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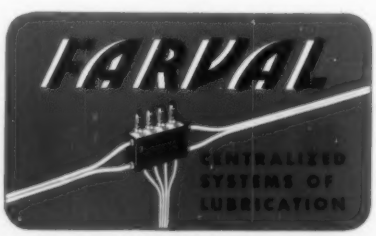

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

December 19, 1960 Vol. 31, No. 52

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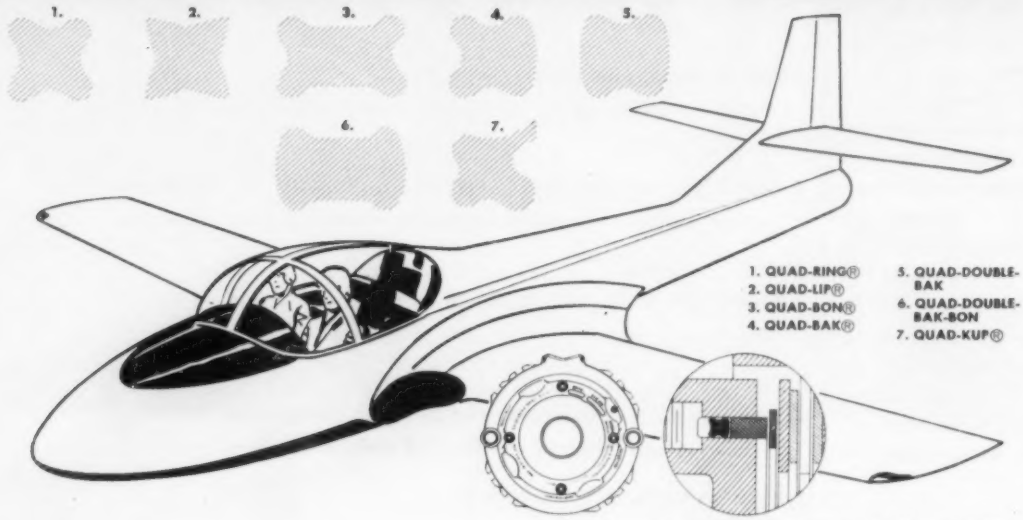

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INTERESTING TO NOTE

On our cover—Microscope reveals contamination found in oil taken from a factory sealed container. Photos by Denver Research Institute (under contract to The Martin Co, Denver Div). Cover designed by McGraw-Hill Photo Studio.

As science gets more exacting, the need for cleanliness and the avoidance of contaminating agents becomes more acute. Many companies have found it necessary to set up "clean rooms" or "white rooms" where temperature and humidity are kept under check and dust particles are held to a minimum. But dust isn't the only source of contamination; as the article on page 35 points out, particles in fluids can also affect a product.

While such contamination is a fairly recent worry, man has always been faced with the problem of locating an uncontaminated source of drinking water. In early days, it was rather simple—a moving stream was usually considered safe. However, when people began gathering in large numbers, cities were formed and the stream that was adequate for a group of several hundred was no longer sufficient. As a result, wells became the common source of clean water. Some of these early civilizations were able to bore surprisingly deep into the earth. For example, Joseph's well at Cairo, Egypt—one of the most famous ancient wells—was excavated in solid rock to a depth of 297 ft.

But as cities grew, wells and springs were not always sufficient. Aqueducts were developed by the Romans and became engineering marvels—examples of the early Roman water system are still in existence. Not only did the Romans develop a water works, but they also developed means of filtration. During the Middle Ages, however, filtration was ignored and polluted water aided the spread of disease throughout Europe. Until 1183, for example, Paris obtained its entire supply of water from the Seine. As late as 1550, the average person in Paris used only 1 quart of water per day, which may give some indication what the sanitary conditions were like.

Even today the search for clean water is a problem in many parts of the world. In the Virgin Islands, the principle source is rainwater caught by large concrete basins built on the sides of mountains. When the water supply gets low, tankers must import water from Puerto Rico.

Before the Kart

Sports cars have joined the trend toward compactness with a new offshoot—the small, bare, four-wheeled racer called a "go-kart" or just plain kart. It's about the size of a child's pedal car, but it can hit speeds up to 70 mph. Designing these small racers presents some interesting problems (see p 38). Although the kart is relatively new,

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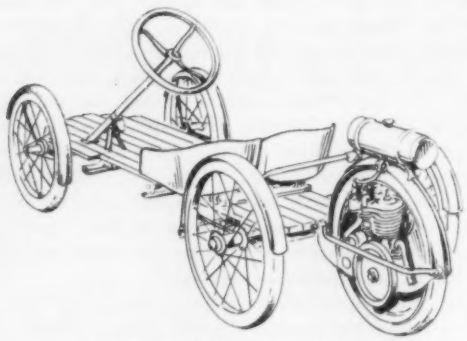
its principle dates back to a machine called the "flyer" or "buckboard" manufactured in 1916 by A O Smith Corp.

The buckboard was a wooden slat platform with four wire wheels and pneumatic tires. It was conventionally steered but powered by a motor attached to a fifth wheel at the rear of the platform. According to early sales literature, "a lifting device is provided for the purpose of taking the motor wheel off the ground when the rider wishes to come to a standstill without stopping the engine.



Artists rendition of "Buckboard."

When ready to start, the driver lowers the lifting device and the motor wheel drops to the ground and you immediately start off on your journey." The buckboard could hit a top speed of 25 mph, but was not built as a racer. Back in 1918 the kart, complete with motor, cost less than $150.

A O Smith built only about 500 of them, getting out of the business because the factory space devoted to the buckboard could be more profitably used for a growing auto-frame business. Today there are only about a half dozen of those ancestral karts known to be in existence.

When V Stood for Vengeance

The gyroscope, heart of modern missiles and subject of the article on page 42, was first used in torpedos—by accident. In 1896, Navy engineers were working on a high-speed torpedo. To increase power, they added a flywheel to the propulsion mechanism, and received an added bonus. Not only did the torpedo travel at good speed for several hundred yards; it traveled straight, thanks to the gyro effect of the flywheel. Since then gyroscopes have been standard equipment on all torpedos.

Gyros have been equally important in the field of missiles. The role of the gyro control system is discussed in the biography of Wernher von Braun, *Reaching for the Stars*. During the late 1930s von Braun was working on the A-3 rocket near Kummersdorf, Germany. After several failures, it was decided that there was something wrong with the gyro control system. An ex-Austrian naval officer named Boykow was called in by von Braun to solve the problem. Although he had been trained as a sailor, Boykow had resigned his commission to become an actor. He remained a thespian for several years before the first World War put him back in uniform. He had a brilliant mind and took a particular interest in gyroscopes, securing hundreds of patents in that particular field. Only principles interested him—he scorned details of design or operation. In time, the A-3 rocket was redesigned, successfully, incorporating Boykow's improvements, and renamed A-5. The designation A-4 was left open—to be applied to a more ambitious project that might follow A-3.

On September 6, 1944 the first of these A-4's was successfully launched from the Netherlands against England. Built by von Braun and his associates and using the gyro principles designed by Boykow, this aerial missile soon became known as the V-2 (for "Vengeance Weapon No. 2"). Its vengeance predecessor was V-1—the so-called "buzz bomb." —Benedict A Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Designtown, USA**

In this Special Report, PRODUCT ENGINEERING makes a study in depth of the design engineer. What's he like? What does he think of himself and his job in a typical American city?

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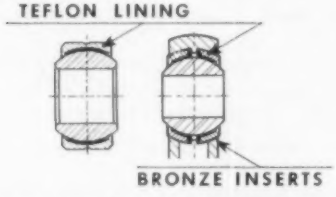

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DEVELOPMENTS TO WATCH . . .

Frictionless flowmeter offers high accuracy at low rates

An impeller-type flowmeter that operates virtually without friction, and is as accurate at low flow rates as in the normal range, is claimed by Britain's National Engineering Lab.

Credit goes to a hydrostatic pressurized bearing. Lubricated by the liquid being metered, it develops a dynamic water film between rotating and stationary parts that "eliminates all static friction and permits a wide range of rates of flow to be metered with linear response."

Speed of impeller rotation is measured by counting electrical pulses. These are generated by a magnetic-toothed wheel built into the impeller, and counted as the wheel moves past the pole shoes of an electromagnet built into the bearing. With the arrangement, says NEL, bearing and pickup, which are the only parts requiring accurate alignment, are automatically held together. Furthermore, it is hoped that precision molding of the impeller will eliminate the need for individual meter calibrations.

Glass reinforces metal for reactor use

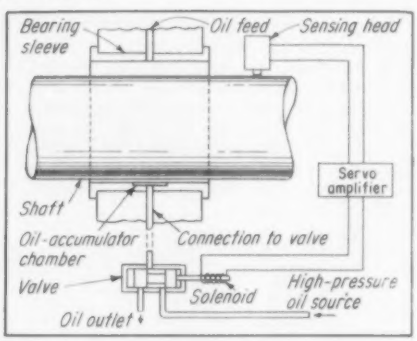
Glass-reinforced metal parts can be produced, says W. L. Morgan of Owens-Corning Fiberglas, by coating the fibers with metal, bonding them to form sticks, cutting them into pellets and compacting them into the desired shape. The properties of the finished compact can be varied considerably, by using different metals for coating and bonding. Powdered metal may also be used to aid compacting. Combining glass and metal this way, says Morgan, increases the strength of the metal, and at the same time prevents self-abrasion of the glass. One possible application: fiberglass fuel elements for nuclear reactors (*PE*—Mar 14, p 8).

Micro-porous tape permits air passage

Tape that "breathes"—pressure-sensitive tape with millions of tiny holes to permit the passage of air—has been developed by Minnesota Mining & Mfg Co. It has a nonwoven, random-web rayon backing and a special polymer adhesive. First applications will be medical (breathability prevents skin irritations); but it may solve other problems.

Constant-clearance bearing minimizes position errors

A fluid bearing system for machine tools and other precision equipment uses a sensing head to detect shaft movement and control the thickness of the oil film in the loaded region.

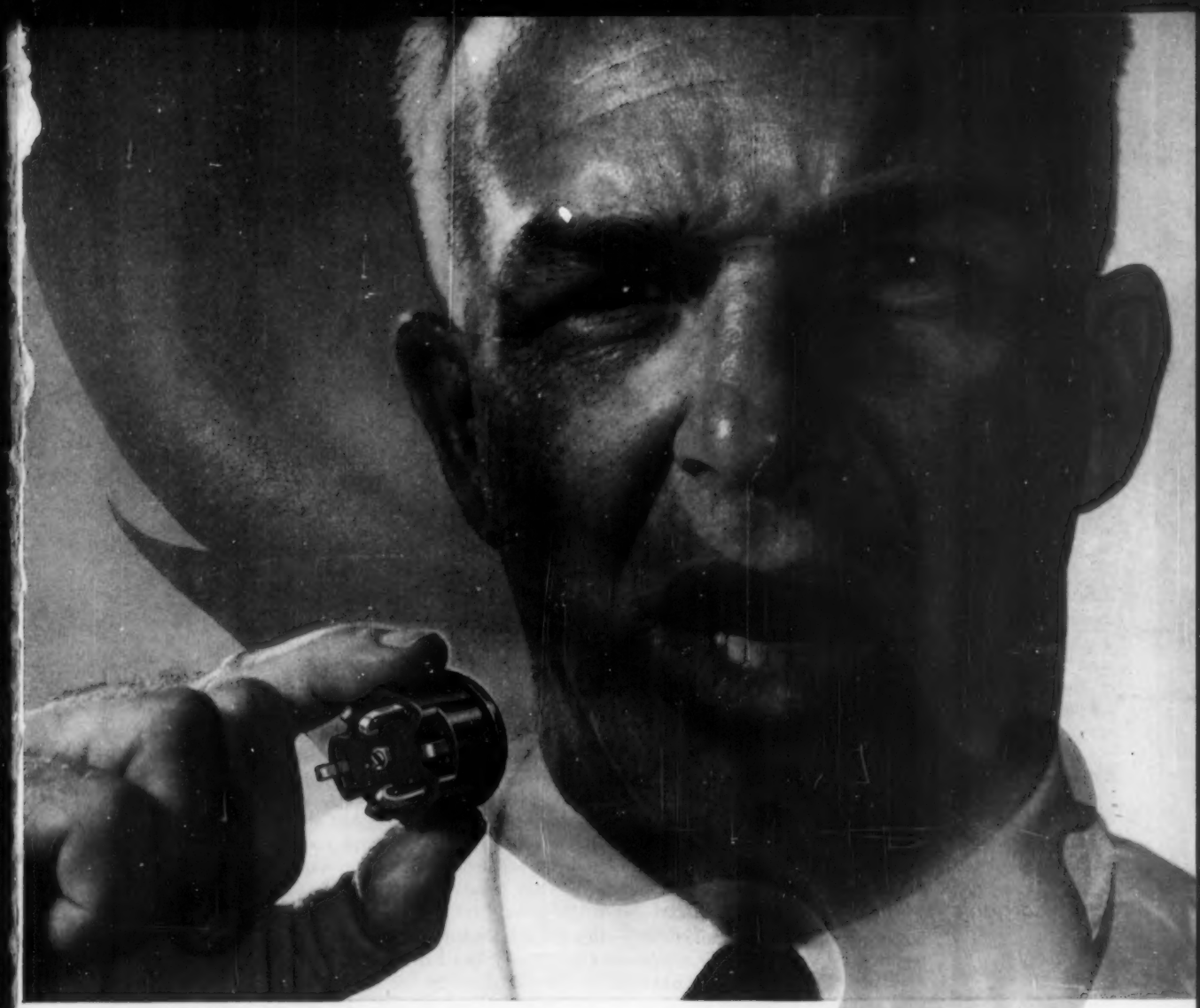


The sensing head provides an electric, hydraulic, or magnetic signal to operate a valve connected to the bearing's oil supply. Then, if the load or speed are such as to cause a thickening of the film, the valve opens, bleeding off excess oil, restoring the clearance and maintaining shaft position. Where bearing design does not permit oil bleed-off under normal load conditions, a two-way valve may be used to supply high-pressure oil to the loaded region (see diagram).

For machine-tool applications, the system can be arranged so that the sensing head is actuated by the position of the cutting tool supported by the bearing, thus compensating for elastic deformation of the machine structure.

Information on the device (case #1174-59), designed by A. Cameron of London's Imperial College, may be obtained from Britain's National Research Development Corp. US Representative: Philip Wright, Suite 503, Mercury Building, Washington 6, DC.

continued, p 8



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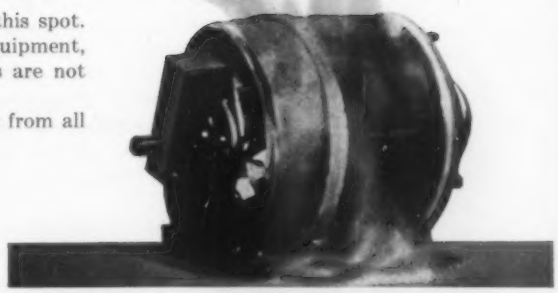

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ON SINGLE- AND 3-PHASE MOTORS

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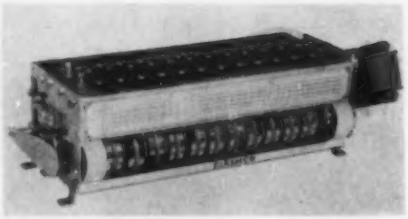
CIRCLE 7 ON READER SERVICE CARD

Automatic timers control multiple circuits



A new series of controllers that will handle as many as 12 continuously and independently adjustable timing circuits, and will reset to zero within one second, is being introduced by Electrical Remote Control Co Ltd, Essex, England. Designed for operation on 110, 230 or 460 v, 50 or 60-cycles, they have a switching capacity of 15 amps at 230 v.

Interchangeable motors and gears allow altering the maximum timing range from 10 sec to 30 days; and calibrated drum dials make it possible to preset individual timing circuits. The timers (known as type MAT/RM/RS) have both a reversing electromagnetic clutch and a reversing motor. Previously introduced units featured either one or the other. Prices range from about $106 to $370, depending on the number of circuits to be controlled.

Soviets report progress in electromagnetic blasting

Nonexplosive methods for rock drilling and blasting have been under investigation in the Soviet Union for a number of years (*PE*—Dec 15 '58, p 6) and now seem close to large-scale application.

The latest Soviet report, in *Ekonomicheskaya Gazeta* says an electromagnetic oscillator has now been built that "produces an effect equivalent to that of the strongest explosives" and can transform an ordinary rock-loader into a crushing and cutting unit. Rate of cutting is expected to be "several meters per hour," and this, the inventor A. V. Varzin, believes, can be increased considerably if a way can be found to expedite rock removal. Furthermore, he says, the power requirement per cubic meter seems quite low. He thinks less power will be required for his electrode device than is now used for the drilling of blast holes.

New organic coatings for outer space

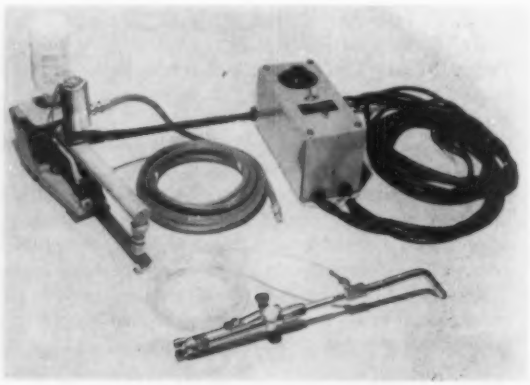
Organic temperature-control coatings suitable for extended service on space vehicles are reported by Wright Air Development Div. Two types have already been tested on space probes; and a third, a ferrocene derivative said to be "the first material ever reported with complete ultraviolet stability," is now being readied for test. Furthermore, says R. M. Van Vliet of WADD, this new compound may form a building block for plastics and organic coatings that can stand long-time space exposure, as in space stations.

New equipment to cut hardfacing costs

An oxyacetylene unit that sprays hard-surface materials in powder form and fuses them at the same time is being introduced by Air Reduction Sales Co. It's a simple unit—basically a control panel with rheostat and rectifier, and a powder feeder and vibrator assembly (see photo). A standard welding torch is used, but with a modified tip.

Use of the carrier gas, says Airco, makes the unit independent of gravity; and, for many alloys, the powder is less expensive than wire. The unit can also be used for brazing. Suggested applications: pistons, valves, blade guides, and other engine and pump parts.

—ARG



POWDER SPRAY ASSEMBLY (left) is key element in oxyacetylene hard-surfacing. Control panel is at right.

WHAT'S HAPPENING IN RESEARCH . . .

Nylon wins in permeability tests

In a series of tests that compared the gas permeability of half a dozen commonly used plastics, nylon turned out to be the winner.

The tests, conducted at Britain's Atomic Energy Research Establishment at Harwell, were designed to find the least permeable materials for use in vacuum equipment. Samples of the plastics were used as dividers in a cylinder, with atmospheric pressure on one side and a vacuum on the other. The amount of gas flowing through from the high side to the low was used as the index of permeability.

Five gases were employed in the tests: hydrogen, helium, nitrogen, oxygen, and argon. Nylon showed the lowest permeability for all of them. Four of the plastics (nylon, acrylic, polystyrene and polyvinyltoluene) did very well with nitrogen, oxygen, and argon. The variation in permeability to hydrogen and helium, though, was considerable. One type of nylon had an index of 1.6×10^{-11} for hydrogen and 3.7×10^{-11} for helium; while polyethylene showed a hydrogen permeability of 1×10^{-8} and a helium permeability of 7×10^{-10}. PTFE (fluorocarbon) had a hydrogen index of 2.4×10^{-9} and a helium permeability of 7×10^{-8}.

A report on the study (AERE M599) has been prepared by R. S. Barton of Harwell and may be purchased from H. M. Stationary Office (London).

India reports new low-zinc brasses

Brasses containing less than 50% copper and little or no zinc are under test by India's National Metallurgical Laboratory. The aim: to develop sheet alloys that will minimize use of scarce materials, notably copper and zinc (*PE*—Dec 12, p 8). In place of these elements, substantial quantities of manganese are used—as much as 40% in some cases.

Tests so far indicate good hot- and cold-workability, and excellent deep-drawing properties. But NML says manganese does have a marked effect on thermal conductivity. Further work is now in progress, testing the effects of small additions (2 to 5%) of such other elements as aluminum and nickel, and attempting to determine optimum content for the major elements.

New way to predict electrical failure

Inclined-plane testing is making possible rapid evaluation of the resistance of insulating materials to failure by tracking or scintillation erosion in the presence of conducting liquids. E. J. McGowan and K. N. Mathes of General Electric's General Engineering Laboratory report. Such contaminating liquids, while they may not directly cause corrosion or degradation, can result in progressive electrical failure by "tracking" because the liquid acts as a conducting path between carbon particles on the surface of the material.

For the test, a sample is mounted at a 45° angle to the horizontal. Electrodes are fastened to the surface, contaminant is fed through a flexible plastic tube. The bottom electrode has a series of "teeth" bent to make spring contact with the sample surface and yet permit passage of contaminant without a "dam" effect.

With the sample in position, voltage is increased until tracking failure occurs, and this point is used as the critical one.

To obtain reproducible results, several factors, including concentration of contaminant and rate of flow, must be carefully controlled; but, McGowan and Mathes say, this can be done, and good reproducibility of results has been achieved.

The fact that the method cuts testing time from days or weeks to a few hours should make available much more data than has previously been accumulated on this often overlooked source of electrical failure.

What's rubber?—the latest definition

It's not "rubber" if it doesn't stretch at least 100% and then return to within 10% of its original length after being held in the elongated position for 5 minutes, says the ASTM.

In its latest revision of *Definitions of Terms Relating to Rubber*, it characterizes rubber as "an elastomeric material that can be or already is modified to a state exhibiting plastic flow, and quick and nearly complete recovery from an extending force"—hence the importance of the stretch test.

Also covered in the ASTM tentative specification (D1566-60T): *abrasion resistance index, swelling, tear strength.*

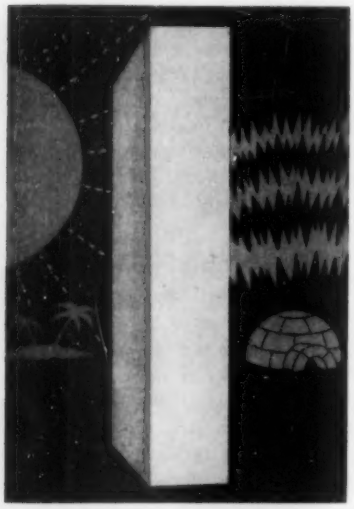
brief . .

Water's triple point (where liquid, solid, and vapor coexist) has been set at 0.01 C. By agreement—at the Paris conference on weights and measures—this was adopted as the official figure. It's equal to 273.16 K or approximately 32.02 F. For most calculations, though, the old round numbers will still do. —ARG

Trio of mikes provides high-accuracy positioning

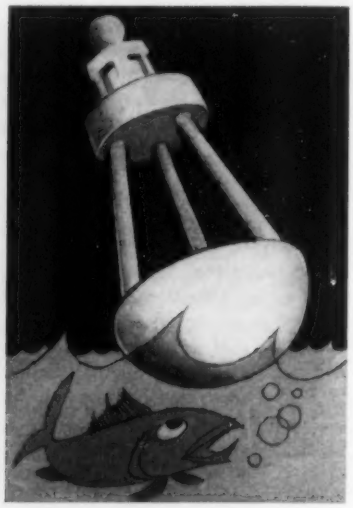
A 3-plane positioner, with micrometer controls in all three planes, and a range of movements up to ½ in. is being offered by Kulicke & Soffa Mfg Co, 1234 Callowhill St, Philadelphia 23. The standard model, priced at $200, has 0.001-in. micrometers, but 0.0001-in. calibrations or metric assemblies can be supplied on special order. Weight of unit: 5 lb, 10 oz.

Five reasons why so many designers select



It's an insulator

The Thermal Conductivity (K Factor) of DYLITE is 0.242 at a 75°F. mean temperature at 2 lb./cu.ft. density. DYLITE resists heat, is unaffected by moisture condensate. Cooler chests molded of DYLITE keep food and beverages cold for days without ice refill. DYLITE is easily molded to fit contours of component parts of refrigerators, air conditioners and freezer cabinets.



It's waterproof

At 2 lb./cu.ft. density, DYLITE's rate of Water Vapor Transmission is 1.18 perms., and its rate of Water Absorption is 0.54 lbs./cu.ft. after 48 hrs. immersion. DYLITE is ideal for boats, rafts, buoys and other types of buoyant marine equipment. DYLITE remains in the water indefinitely without becoming water logged, and it is mildew-proof.

It's shock-resistant

DYLITE possesses an Energy Absorption ratio (Maximum Load) of 56.74 in. lbs./cu.in. at a density of 2 lb./cu.ft. For example, Royal electric typewriters are now shipped in shock-absorbent DYLITE packages—a result of performance tests in which DYLITE was proved superior to other materials for this job.

TYPICAL PROPERTIES OF DYLITE EXPANDABLE POLYSTYRENE—DENSITY 2 LB./CU.FT.

• Compressive Strength—30 Psi • Tensile Strength—55 Psi • Water Vapor Transmission—1.18 Perms.
• Water Absorption—0.54 Lbs./Cu.Ft. • Thermal Conductivity (K Factor)—0.242 at a 75°F. Mean Temperature
• Energy Absorption (Maximum Load)—56.74 In.Lbs./Cu.In.

DYLITE is a registered trademark of Koppers Company, Inc.

DYLENE® polystyrene, SUPER DYLAN® polyethylene and DYLAN® polyethylene are other fine plastics produced by Koppers Company, Inc.

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DYLITE® expandable polystyrene

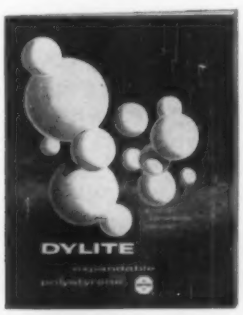
It's lightweight

DYLITE is lighter than cork—it can be molded in densities of 1 to 10 lb./cu.ft. The advantages of light weight are obvious. In packaging, DYLITE helps reduce shipping costs and makes handling easier. In the construction field, where DYLITE is used as an insulator, its light weight means fast and easy installation.

It's strong

DYLITE has a Compressive Strength of 30 psi and a Tensile Strength of 55 psi at a 2 lb./cu.ft. density. DYLITE can be used to great advantage in a wide variety of industrial design problems. For instance, sandwich structures that employ DYLITE as the core material offer high strength without sacrificing light weight.

... if you would like more information about versatile DYLITE expandable polystyrene, write for this free booklet.



Koppers Company, Inc.
Plastics Division
Dept. PE 12190,
Pittsburgh 19, Pa.

FROM WASHINGTON . . .

Fiberglass favored for Polaris motor casing

Fiberglass may be edging out metals as the motor-casing material for the Polaris missiles. The light weight of the material is the big attraction. **A ¼-scale model on the second stage Polaris A-2 missile—to go 1500 miles—is under test now.**

Engineers working on the project say the material has performed much better than steel casings, and about as well as titanium casings. There is still interest in titanium. But its high cost may tilt the decision to fiberglass.

Fiberglass is used in part of the upper staging of other rockets, too: the National Aeronautics and Space Administration's Scout solid-propellant rocket and the Air Force's Minuteman ICBM.

Navy engineers working on the Polaris program are saying now that they can extend the range of the missile without having to redesign firing tubes. They will do it with lightweight casings and a new higher specific-impulse propellant known as 2056-D. Earlier, the Navy thought it would have to add about two feet to the length of the submarine firing tubes in order to handle the second- and third-generation Polaris missiles (A-2 and A-3), which will have 1500-mi and 2500-mi ranges.

This would have meant refitting first five Polaris submarines with new tubes to handle the longer range missiles.

Engineers to use computer in design

Design engineers may benefit from a new electronic computer-plotter recently unveiled by the US Weather Bureau. Developed by Electronic Associates Inc of Long Branch, NJ, the system takes readout information in numerical form on magnetic tapes, pushes it through a digital-to-analog converter, then feeds it to a mechanical plotter that can plot curves continuously.

The Weather Bureau has installed two 30 x 30-in. plotters and has ordered a 49 x 60-in. model. Plotting system is accurate within 1/15,000 in. A plotter can be built up to 150-in. in width, Electronic Associates says.

The company says design engineers could feed into a digital computer, the design of a free piston engine, and have the plotter draw the shape of the engine; then crank in variations in design and have them printed out within minutes.

NASA, bickers with industry and military over satellite-program plans

Commercial space-communication satellites have touched off a round of controversy. **At the center of the hassle is the National Aeronautics and Space Administration (NASA). Recently it announced that it was starting an active communication-satellite program in addition to its passive communication Project Echo program.**

The military, with active communication-satellite programs already underway with the Army's Courier and Advent series, immediately foresaw the move as a threat to future Congressional appropriations for their program. And, they have quietly been bucking the NASA entrance into the field.

Industry, with its own plans to put up commercial communication satellite systems, is afraid the NASA move will force delays until the agency spells out some details of its program. This won't come until next year when the agency goes before Congress for the necessary money.

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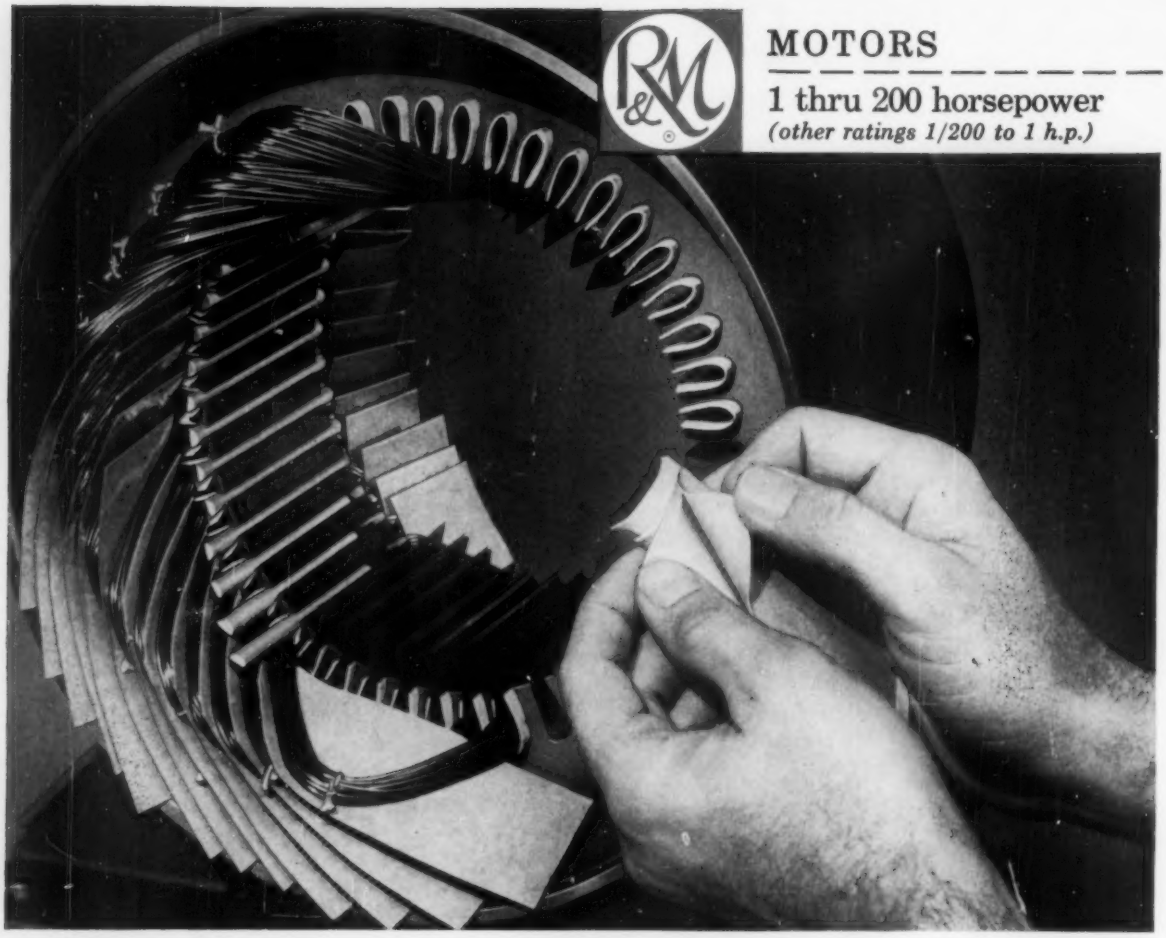

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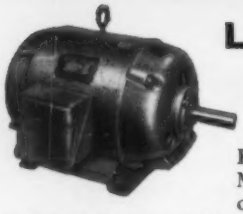
1 thru 200 horsepower

(other ratings 1/200 to 1 h.p.)



Locked-In, Laminated Insulation

Insures Longer Life for your R&M Motor!

Each slot-cell in your ROBBINS & MYERS motor grips a triple layer of insulation around the windings. Installing these insulation "sandwiches" is a time-consuming job but it pays off in long motor life. Mylar* laminated to rag paper is first inserted. Reinforced edges prevent slipping and scuffing. The dielectric qualities of Mylar* (8 times that of conventional insulation) combined with its resistance to tearing and aging affords permanent protection; the rag paper backing acts as a cushion against abrasion and punctures. A second layer of insulation is inserted to eliminate the danger of weak spots. The wire coil, coated with triple resin insulation, is inserted and a third layer of insulation is placed over it. Insulation is placed between the coil ends, wedges are inserted to hold the coil firmly in place and the stator is twice dipped in special insulating varnish and baked after each dip, thus forming an armor-like coating. Coil ends are coated with a moisture-proof sealer. This is insulation you can trust, yet it's yours at standard prices! For more details write for Bulletin 520 PRE

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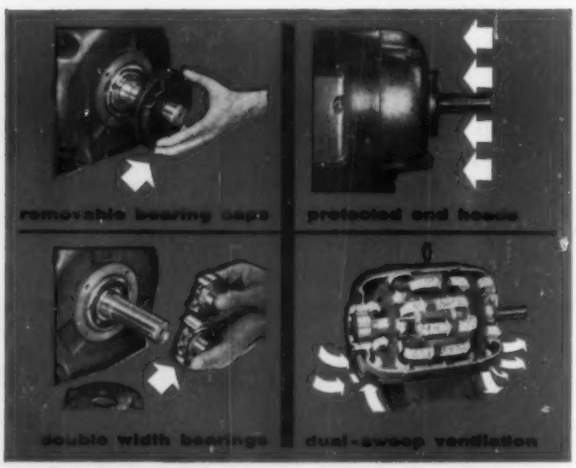

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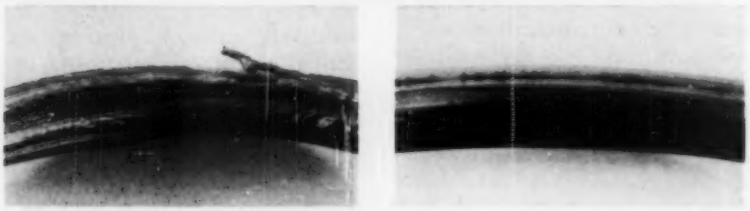
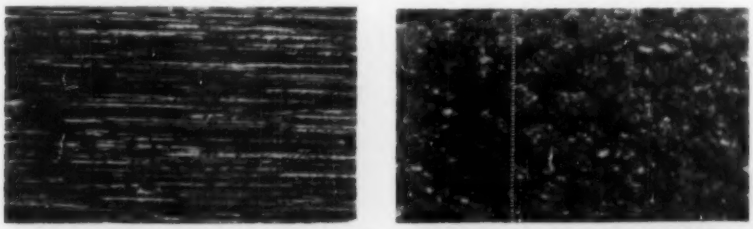


EFFECT OF NEW SEAL DESIGN and shaft finish on seal life is apparent after running both the new design and the old one on a 1⅛-in. shaft at 6500 rpm for 20 hr. Left: standard seal on a ground shaft is ragged after running 20 hr at 500 psi. Right: Vickers' experimental seal after 20 hr at 1000 psi virtually eliminates wear of the rubber element.



UNDER MICROSCOPE, a standard ground shaft (left) shows ridge-and-valley structure which tends to lacerate rubber lip of the seal, reducing its life. Wet blasting with tiny glass beads produces (right) a discontinuous, shallow surface-pitting on the shaft, eliminates microscopic sharp edges and directional grooving caused by grinding.

Less Leakage Now with Shaft Seals

DETROIT—New seal design and a new method of finishing the surface of a rotating shaft have combined to reduce seal leakage at high pressures and operating speeds, according to Vickers division of Sperry Rand Corp.

Analysis of seal failures showed that major problems were: (1) short life of the rubber lip, and (2) variation in leakage rate. Earlier investigations pointed up the need for a metal back-up to the sealing element, with metal close to the shaft to reduce the surface in which rubber alone opposes high pressure.

In addition, the problems of shaft run-out, bearing clearances and wear have led to a random displacement of the shaft in the seal. With a stationary back-up ring, this displacement causes a combined extruding and shearing action which reduces effective life of the lip seal.

In the new design, say Vickers engineers, the back-up ring is prevented from rotating but free to move a small distance radially. The back-up ring therefore tends to follow rather than oppose shaft movement (sketch).

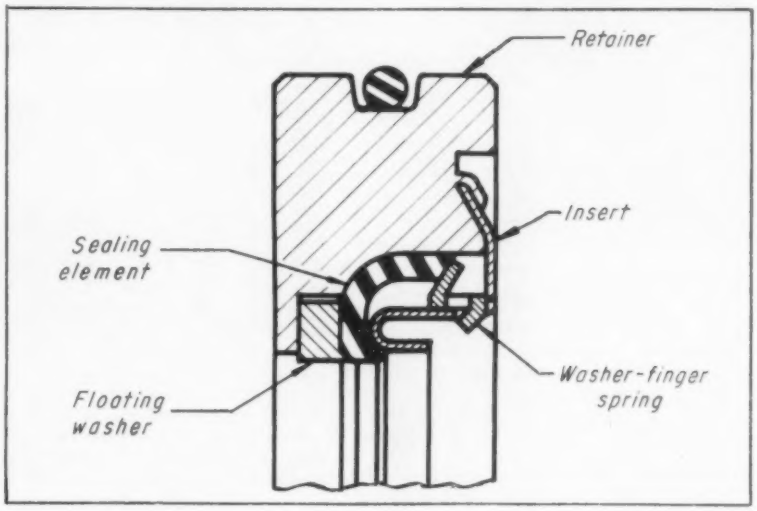
Study of the effect of shaft finish on the rubber element indicated that damage occurred when two seals were run successively on the same shaft—the second seal lasts longer than the first before a given level of damage is reached. As the seals were identical, the longer life of the second seal was attributed to improvement in the shaft surface. The first seal apparently "broke in" the shaft by smoothing out minute defects in the surface.

Damage to the rubber element was noted in nearly all accelerated tests at 1000 psi. Under magnification the surface of the ground shaft has the appearance of a knife's edge. The slicing effect of these sharp edges apparently causes damage to the rubber element. Also, circumferential grooves from grinding apparently provide a continuous path for escaping fluids. In addition, a "pumping action" is believed introduced by the rotation of the grooves, resulting in even greater seal leakage than is caused by the fluid pressure against the seal.

Several finishing techniques were tried, including light buffing after grinding, acid etching, reverse etching of chrome, and wet blasting using a powder-like material consisting of ultrafine glass beads. The last technique, developed in cooperation with the Wheelabrator Corp, gave shafts that produced less damage in the rubber element at high pressures, further reducing leakage at all pressures.

Photomicrographs of this blasted surface show a pattern of tiny pits forming a discontinuous and nondirectional type of surface. These small pockets trap liquid and impede its travel past the seal. The pools of fluid also provide lubrication.

—Felix Giordano, Detroit Bureau



Teaching-machine Industry Foresees Design, Sales Problems

SAN FRANCISCO—The teaching-machine industry has by now developed a community of problems sufficiently serious to hold an industry-wide technical and management conference. The first such confab was held here at San Francisco State College and drew 75 participants from 20 states.

Purpose was to summarize state of the art and provide a forum for exchanging ideas and experiences. Manufacturers of the machines sponsored several laboratory and workshop sessions for demonstrations. Companies taking part included three from the California area—Rheem-Califone Corp, Hollywood; Western Design, Santa Barbara; and Corrigan & Associates, Fullerton—and Teaching machines Inc, Albuquerque, NM.

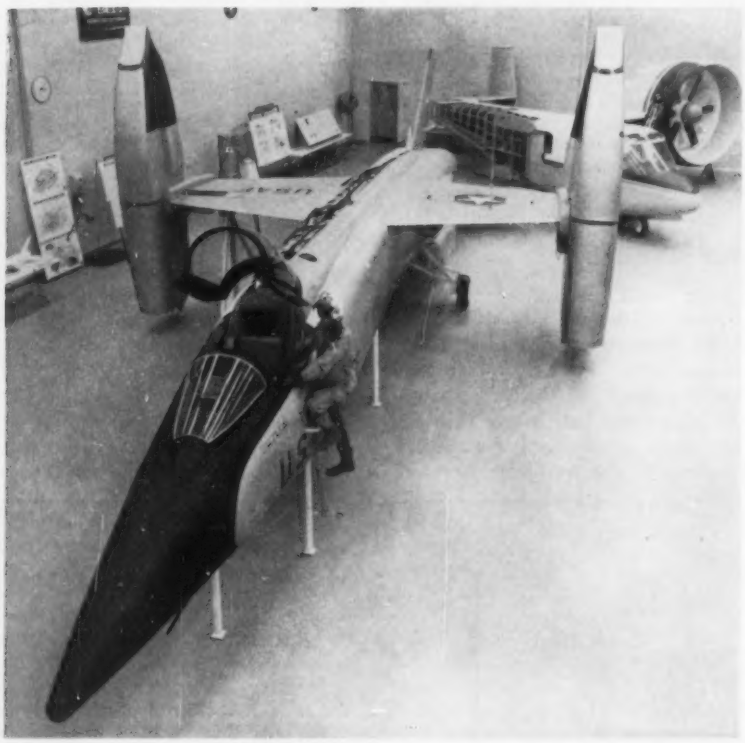
According to a brief poll of participants, the teaching-machine industry will gross from $8 to $10 million in 1961, its first year of concerted operation. But one source said that growing demand for the machines is forcing some manufacturers into production before they have had a chance to develop their machines—or even their theories—to their own full satisfaction. This, he said, may lead to an early slump in the industry while manufacturers catch up with their own technology and fight the prejudices sure to develop early against the machines.

The line that the industry will take to defend teaching machines became apparent at the meeting. Most criticism on the academic level holds that such machines become impersonal once they develop beyond the audio-visual aid spectrum. However, the feeling is that current emphasis on subject matter in schools fits into development of the next generation of teaching machines—the data-reduction type.

"This will free the teacher from pouring out basic facts, and from becoming a clerk when it comes to grading exam papers," according to representatives of Rheem-Califone. "That means that with the help of teaching machines, teachers will be able to go more deeply into their subject matter, for machines will give students the basic knowledge on which to build in open discussions."

Few teaching machines have so far been marketed for industrial training, but programs for office trainees and even lathe and machine apprentices are in the works. A key-punch trainer has been used with success. ■

A Mach 2 Jet With V/STOL



A supersonic jet fighter-bomber designed to exceed Mach 2 in flight and with V/STOL (vertical and short take off and landing) capabilities is being built by Bell Aerosystems Co of Buffalo for the Navy and the Air Force. The single-place D188A, shown is a full-scale model and is powered by two J85 turbo jet engines mounted at the tip of each wing and by four more J85's in the fuselage—two horizontal ones at the rear and two vertically positioned lift engines forward. During V/STOL, hovering and transition flight, the pilot controls the plane by a reaction system which uses engine-bled air to control yaw and roll. Pitch control is obtained by modulating the fuselage engine thrust. The 25,000-lb aircraft is 58.6 ft long, 12.9 ft high and measures 23.8 ft wide. Bell engineers say the D188A can take off vertically and complete its transition to horizontal flight in 60 sec.

Productivity Experts Mull Latin American Problems

SAN SALVADOR, EL SALVADOR—Representatives of productivity centers from seven of the northernmost Latin American nations have met here to lay plans for stimulating their mutual industrial development. Their aim is to avoid duplicating capital investments within the area and to keep one another abreast of national industrialization programs.

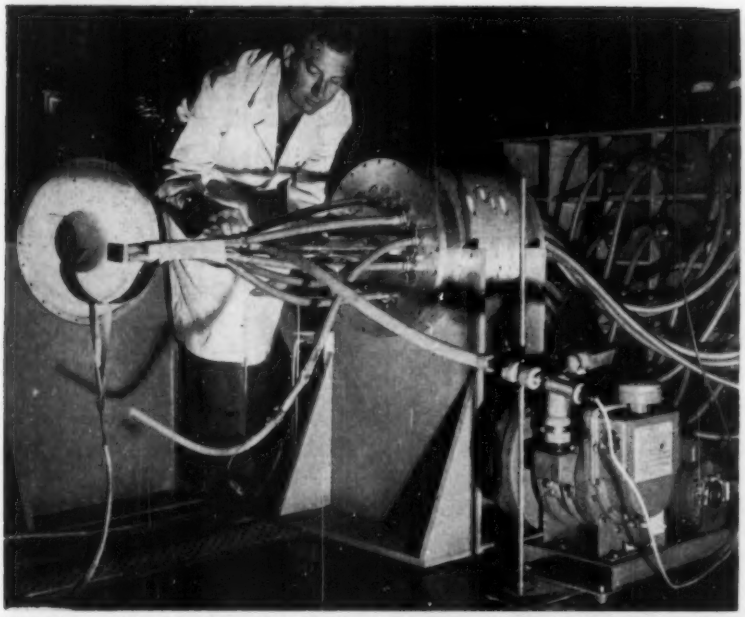
The participating countries were Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Colombia. A US Point Four administrator participated as one of the sponsors of the meeting. Panama declined for unannounced reasons.

Before ending its sessions, the group agreed that each country should send its views on a proposed Inter-American Institute of Productivity to the Organization of American States in Washington.

The five participants from Central American republics also agreed to urge their Ministers of Economy to set up a commission to analyze existing laws of industrial development and draft a uniform law "in accordance with the needs of the Central American isthmus."

—Henry Lepidus, World News

A-blast Shock Waves Studied



This Boeing Airplane Co switch checks shock-wave effects of simulated nuclear blasts on experimental materials. It has a capability of 100,000 v and 1 million amps. Here the power from a condenser bank (right) is triggered into the switch (center) after a vacuum pump (foreground) has pulled down air pressure inside the switch. The vacuum contains a series of 27 circular stainless steel plates, each 6 in. dia, and is maintained at about 50 microns so there will be enough air particles to conduct the current but not enough density to transmit shock waves that could damage the switch internally. A second switch, soon to be unveiled, is expected to give the Boeing Plasma-dynamics Lab 200,000 v of switching capability.

Test Tires Leave Telltale Trails

Experimental tubeless tires are made of Neothane, a polyurethane rubber used mostly in gaskets, gears and solid-type tires. They require no fabric, splices or layers in their construction. According to Goodyear Tire & Rubber Co engineers, the liquid Neothane along with a special dye is poured into molds, emerging in a color-translucent form. Bulbs mounted on the inside of wheel rims plus the translucence of the tire produced the swirls of light in the time-exposure photo above. Goodyear hopes the new tire will last longer and give a smoother ride but its appearance on the market is perhaps 10 years away.

NSF Finds Gains Continuing in Technical Employment

WASHINGTON—Industry added nearly 7% more engineers and scientists to its employment rolls between Jan 1959 and Jan 1960, according to the National Science Foundation. This compares with a 5% increase in the preceding year.

The NSF figures are based on a survey of 10,000 business firms. They are still preliminary and revisions may be forthcoming.

The survey showed physical scientists accounted for the largest proportional increase in the 12-month period ending Jan 1960, but engineers were employed in much greater numbers. A few more life scientists are finding positions in industry, but the increase is modest in comparison with the physical specialties.

The NSF survey reveals that engineering employment rose 40,000 to 656,300—a 6.6% increase. Employment of all types of scientists rose 7.1% to 159,000. Within the scientific group, employment of chemists climbed 7.6% and other physical scientists 9.0%.

Nearly 40% of the engineers and scientists in industry are engaged in R & D, the NSF finds—significant increase over previous years.

Two industries—electrical equipment and aircraft—each employed more than 100,000 engineers and scientists last January. Other industries employing more than 50,000 of these technical persons included chemicals, machinery and petroleum products. ■

UK Machine-tool Makers Win Contract to Supply Soviet

LONDON — Despite recent publicity and Parliamentary debate over a report claiming that the Russians were well in advance of the West in machine-tool design and production, the Soviets have turned to the British for precision gear-hobbing machines.

David Brown Industries Ltd announced that it has signed a contract with Stankoimport, Russia's machine-tool export-import agency, to sell it $1.4 million worth of these machines. The equipment, designed by Brown in collaboration with EMI Electronics Ltd and the Mechanical Engineering

Research Laboratory, is equipped with "super accurate" electronic control systems not available in the USSR. The contract was won in the face of competition from the Russians themselves as well as from West German companies; it will be fulfilled in roughly two years' time. A further order from the Russians of some $700,000 worth of these machines is being negotiated. And a $700,000 order for similar machines from Communist China, contracted about 18 months ago, was recently completed.

Earlier this year, the Melman Report, prepared for the European Productivity Agency by Prof Seymour Melman of Columbia Univ, kicked up an inquiry and Parliamentary debate when it blasted the west European machine-tool industry as inefficient compared with the Soviet Union. ■

"Seeding" Process Produces Cheaper Quartz for Electronics

NORTH ANDOVER, MASS—Western Electric Company is growing its own quartz crystals nowadays, and may save $500,000 annually. These crystals, which are essential elements in carrier equipment for multiple-message transmission over the same pair of conductors, are being produced at WE's Merrimack Valley Works. Until now, WE has depended on Brazil as the source for the natural material.

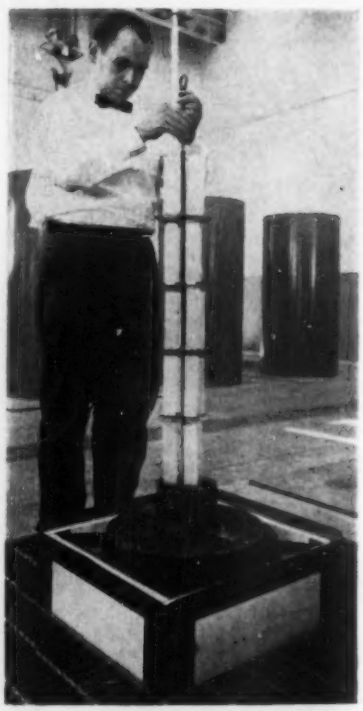
According to WE engineers, the grown crystals—up to 5½ in. long and weighing as much as 1¼ lb—are free from inclusions and such natural flaws as twins (two crystals symmetrically aligned as mirror images of each other). The synthetic crystals are grown so that they have more usable area—at least 2½ times that of the natural crystals.

After crystals have been sliced, cut and etched into the required thin sheets, only 3% of the natural quartz is usable for electronic purposes. This raises cost from $30 per lb for the raw quartz to a finished price of $1500 per lb. The synthetic crystals lower this cost substantially.

In the growing area (right), 20 cylindrical vessels, each about 10 ft long and 1 ft dia, are sunk below the surface of the floor. Into each vessel is lowered a long wire basket. "Seed" crystals of natural or artificial quartz are suspended in tiers at the top of the basket. The lower half of the basket is filled with small, inexpensive pieces of natural quartz. In this form, quartz is readily available from many sources but is unsuitable for communications purposes.

To begin the growth cycle, a weak alkali solution is poured into the vessel, which is then sealed. A heavy steel shield is lowered over the top by a crane for additional protection.

It takes about three weeks of continuous growth to produce a harvest of crystals. Under heat and pressure, the small pieces of quartz at the bottom of the basket dissolve into the alkali solution. Crystals of quartz are redeposited from solution and slowly build up on the "seed" plates at the top of the basket, where the temperature is slightly cooler. ■



SEEDS FOR SYNTHETIC QUARTZ are lowered into crystal-growing chamber. The 6-in. pressure vessel, which operates at 760 F with pressures up to 28,000 psi, is divided into 2 zones: low-grade quartz is dissolved in a sodium hydroxide solution in the lower zone; synthetic crystals deposit onto the seed plates from cooler supersaturated solution in the upper zone. Cylindrical shields in background are added safety precaution.

Ceramic-metal Combination Transforms Heat to Power

WASHINGTON—A thermally activated ceramic-metal combination may solve many power-generation problems in outer space, says Westinghouse Electric Corp's Aircraft Equipment Department. In an initial testing program, explained in a paper before the 15th annual meeting of the American Rocket Society here, a piece of iron coated with ordinary vitreous enamel and covered with a thin silver layer, developed 16 milliwatts per sq in. when heated to between 400 and 1400 F.

Westinghouse further stated that roughly half this output continued as much as one hour after the heat was removed. No temperature differential is required, such as that needed for thermoelectric or thermionic devices. Efficiency of the unit is not yet known, but Westinghouse thinks it will be "rather good." Recharging of the cells is possible and one test unit has been heated 15 to 20 times with good results.

ACCIDENTAL DISCOVERY

The phenomenon is called the "Austin Effect" after B. O. Austin, who accidently discovered it when conducting a series of investigations on high-temperature insulation at Westinghouse. In attempting to determine the insulation characteristics of vitreous enamel at temperatures around 600 F, Austin heated a small slab of enamel steel with two silver electrodes clamped on either side. When the object was measured for resistance, it was discovered that the material was generating a voltage.

The iron base metal was found to be always negative and the silver electrode always positive. The output of the Austin cells depends mainly upon the thickness of the enamel coating. The thickness of the base iron material or the silver coating has little effect on output.

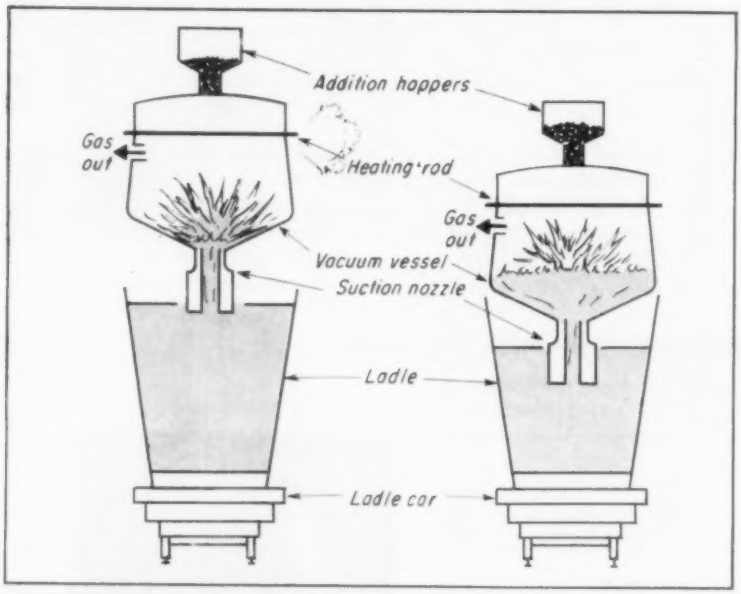
Admittedly, Westinghouse is just beginning to explore its development. But, because of the simplicity and nature of the materials used, the inherently high reliability, low cost and long shelf life of the product, the company believes it has a highly important discovery.

Initially, the company foresees ap-

plications for missiles and space use. Primarily, this would be under conditions of high temperature where conventional power supplies are destroyed or rendered inoperative. For example, the system could be used to produce electrical power from waste heat by integrating Austin cells into rocket nozzle structure; and as a power source during missile-nosecone reentry, with the units activated by reentry heat.

Actually, the use of the Westinghouse Austin cell may prove to be extremely widespread. Typical of the interest exhibited at the American Rocket Society meeting came from an engineer who said he could see at least a half-dozen places in his own work where such a device could be used once developed.

Right now, Westinghouse is in the process of patenting the development and is talking to the military about a developmental contract. In the 18 months that it has been working on the project, the company says it has increased the milliwatt output of the cell some 80-fold. ■



THE DORTMUND-HORDER VACUUM DEGASSING UNIT, making its first appearance in the US, is being evaluated by Crucible Steel Co of America, which says so far the unit appears to be the most economical method of effectively vacuum processing steel. A similar, but smaller, unit is in operation in West Germany and being applied to carbon-steel production. Crucible wants to evaluate contribution of the degassing unit to highly alloyed steels.

European Vacuum Degasser Makes Cleaner Steel Faster

PITTSBURGH — A vacuum degassing unit, which promises to produce cleaner steel faster and with more uniform response to heat treatment, is under test at the Midland Works of Crucible Steel Co of America.

Called the Dortmund-Horder Unit, and appropriated from Europe, the unit eliminates the long, slow cooling cycle customarily used for large sections of certain grades of steel. In addition, it reduces the needed amount of alloying elements, since these can be added in the absence of oxygen, thus avoiding oxidation losses. However, Crucible is still evaluating the unit and no official claims are being made for it.

HOW IT WORKS

First a ladle of molten open-hearth or electric-furnace steel is moved under the vacuum chamber and weighed (see drawing). This permits proper alloying additions to be calculated.

A suction nozzle on base of vacuum chamber unit is lowered beneath the layer of slag while a pumping system rapidly lowers the chamber pressure to about 1 mm. Now, atmospheric pressure causes the liquid steel to rise some 60 in., filling the nozzle. Vacuum vessel is then lowered, forcing the molten steel into the vacuum chamber. Result: a tremendous surface area of droplets of molten steel are exposed to vacuum. When the chamber is raised, the steel which has been degassed flows back into the snorkel.

Inertia causes the treated steel to sink to the bottom of the ladle and forcing untreated steel to the top, where it is drawn up into the nozzle during the next cycle. Unit is raised and lowered repeatedly until the entire portion has been degassed. For a 170-ton open-hearth heat, this takes about 30 min.

During the cycle, carbon heating rods maintain the vacuum chamber at proper temperature. Alloy hoppers around the rim of the vacuum chamber allow the addition of alloys to the steel under vacuum. The steel is deoxidized first, then the alloying additions are made.

Aside from deliberate additions during the process, the significant changes in chemistry which occur are (1) hydrogen is removed; (2) virtually all oxygen is removed; (3) a large portion of the nitrogen is removed; (4) carbon is lowered (the carbon is acting as a deoxidant, and the oxygen is removed as carbon dioxide and carbon monoxide) and (5) some manganese is lost during the cycle.

When the cycle is complete, the chamber is brought up to a partial pressure, using nitrogen as a safety measure before raising the snorkel tube to a point above the slag line where it is open to the atmosphere.

IT HAS A FUTURE

Crucible expects the unit by removing oxygen will improve cleanliness which, in turn, will result in improved transverse ductility, better resistance to fatigue, higher impact resistance, lower ductile-brittle transition temperature as well as greater reproducibility and reliability. These advantages should make the unit welcome in many markets—turbine rotors, bearings, die-casting and plastic mold dies, constructional steels for aircraft and missile applications.

In addition, closer control of chemistries results in more uniform response to heat treatment; while reduction of inclusions should prove better deep drawing, forming and surface finish in flat-rolled stainless steels. ■

POINTS OF VIEW

THE QUESTION:

Have American Standards

"We in Japan, without question, are meeting some inconvenience . . .

Naoshi Hagio
Managing Director, Export Div
Tokyo Shibaura Electric Co Ltd

However, we must face the existing situation and meet customer's requirements, not only complying with the American standards but with others, such as British standards, if we are to export our equipment and machinery.

"Japanese standards are quite similar to American standards. For equipment designed and manufactured to buyer's specifications, we find little or no difficulty in meeting the requested standards, especially those regarding technical performance. Our manufacturing is in accord with the Japanese Industrial Standard (JIS). When necessary we supply the clients with one grade higher in quality.

"Japan uses the metric system whereas America, of course, uses the ft-lb system. This fundamental difference in measurement units is giving us some inconvenience. Though it may be considered a small matter, the difference between the thread size of Japanese and American bolts and nuts forces our engineers to spend many hours discussing the matter with our clients.

"Another problem exists in the underdeveloped countries of Southeast and Middle-east Asia. Owing to the long influence by the European countries, they are following British standards, as well as some French and German standards. Japan must adjust its equipment to the existing standards in these areas as well."

"Britain's problems show international standards are needed . . .

to overcome trade barriers. In many countries, customers are reluctant to accept goods which do not conform to their own national standards. It is unfortunate that some interests in the United States have been reluctant to participate in negotiations for new world-wide standards.

"During the last few years, US interest in the International Standards Organization (ISO) has increased—but there are still many examples where the US is out of step—and all of us, in the UK and the US alike, are losers as a result.

"Take carbon- and low-alloy-steel specifications. Britain lines up with the rest of Europe in demanding close tolerances for physical properties, and allowing fair latitudes in chemical analysis. In America it is the other way around. This often means that where our products are dimensionally suitable, steel specifications do not match, and exporters to the US are often forced to order special steel—resulting in higher, less competitive prices.

"Look at electric-motor standards. We in Britain often build machines using internationally agreed limits of temperature rise. For "Class E" limits, a total temperature of 120 C (80 deg C above an ambient temperature of 40 C) is allowed. "Class A," not "Class E" limits are used in the US; they allow only a 65-C rise, and motor ratings have to be adapted accordingly. We are again immediately less competitive.

"More than ten years ago, the ABC countries (America, Britain and Canada) agreed to adopt unified screw threads. Britain confirmed these new standards in 1953, but America did not publish a separate standard for unified threads until this past summer. The result—manufacturers in other countries have hung back, waiting for evidence of American implementation. Britain carried on with Whitworth threads. What else could we do?

"Another problem facing British exporters is obtaining product approval. Frequently, this is only possible at Underwriters' Laboratories in the US and just think of the problem of, say, a boiler manufacturer who has to ship a prototype across the Atlantic without knowing whether he will have to ship it back again. But by far the greatest contribution the US could make toward easing international trade could be much greater participation in the work of ISO."

T R B Sanders
Engineering advisor
British Standards Inst

Hurt Foreign Manufacturers?

Dr Francisco Vera
Vice-president and economic counselor
Brazilian National Confederation of Industry

"Brazilian sales have not been hurt yet, but . . .

the problem of standards is growing as our industry continues its rapid expansion.

"The most important factors in meeting differences in standards are costs of conversion, increased costs resulting from errors in converting, plus safety and accuracy. For example, to get import licenses, all product characteristics must be shown on documents, in the metric system. This involves costly time in converting when imports originate in non-metric countries. Errors in conversion can subject the importer to heavy customs fines. Then we have the problem of foreign industries, like the automotive, making products designed to US measurement standards for sale in a metric market. In the textile industry, machines are mostly British or American, with capacity ratings in yards, but for invoicing, consumption and sales-tax calculations, all figures must be switched to meters.

"Because these problems are always being discussed by manufacturers, the majority of whom don't maintain personnel specially trained for working out conversions and calculating tables, the National Confederation of Industry is launching a survey among 3000 members to get a quantitative demonstration of the problem and form an organized opinion as to what steps to standardization should be taken.

"Through questionnaires we want to find out just what foreign trade difficulties our members are encountering because of standards differences; whether the chief problems are inventory control, errors, or conversion costs; what changes each would have to make to bring about uniformity; whether the cost of these changes can be estimated and whether a changeover should be made gradually, or all at once.

"Personally, from a cultural point of view I think any move toward bringing greater unity to our civilization is to the good. If we can't have a common language or a common currency, perhaps at least we could have a single common system of measurement. The few opportunities for misunderstanding, the better off we are."

"Europe does things differently . . .

Development trends, product design and, above all, operating conditions and technological requirements, differ greatly between the US and Europe. Obviously, this has been reflected in the specifications and standards practiced on the two continents. Trouble is that not only do the standards vary considerably in their individual definitions and test data, but they also deviate quite appreciably in their classification. Generally speaking, European countries have adopted a system of standards whereby each individual section of technology is governed by a single, all-embracing, and perfectly understandable group of specifications. For example, the electrical trade in England is governed only by BS specifications, in France only by UTE, in Belgium only by NBN, and in Germany only by VDE Specifications. On the other hand, US manufacturers of electrical and allied equipment are plagued with a number of specifications: NEMA, ASTM, IPCEA, Underwriters' Laboratories, and what have you.

"More often than not, US specifications are conflicting and the manufacturer has to consider two or even more sets of specifications before being able to reach a satisfactory manufacturing conclusion. All this means that the mere preparation of a State-side tender for a US project is complicated to the average European. Also, strict US specifications often prevent his using materials or types of materials which are usable in Europe, which he is accustomed to using here, and which have shown themselves satisfactory. However, US specifications have not been an unsurmountable obstacle where a high number of articles is to be produced for US consumption."

Dr Hans J Hilgendorff
Planning engineer
Felten & Guilleaume Carlswerk A. G.
Cologne, Germany

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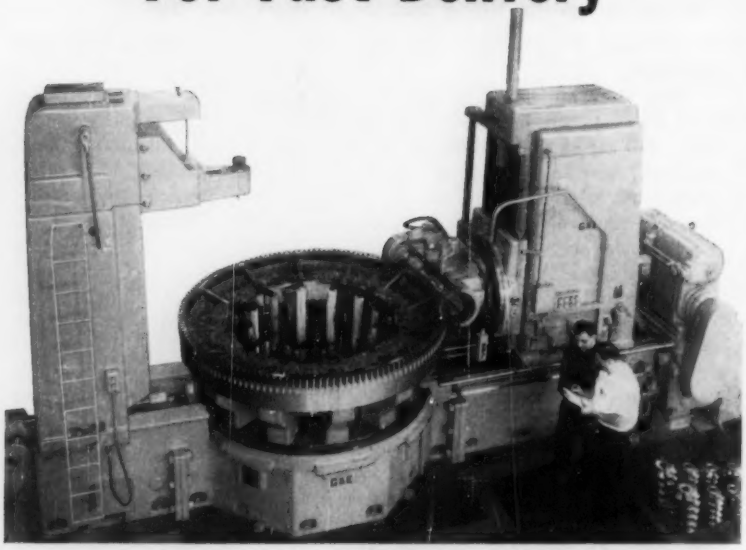

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READER TO EDITOR

English Electric U-core

To the Editor:

The U-core shown in accompanying photos was developed by English Electric Canada, a division of the John Inglis Co Ltd, and has been in use by our company in distribution transformers for approximately two years. We believe that it predates the Sylvania announcement on p 83 of your issue of July 18.

Our U-core forms the basis of an efficient and quiet distribution transformer in sizes from 3 to 200 kva single phase,

and achieves its performance principally from the fact that the laminations are not bent or strained in the restacking process, and are completely relaxed in the final assembled transformer.

While our distribution transformers are in regular production for the Canadian market, they have not been sold or previously announced in the US, though they are available for sale in the US market through the English Electric Export & Trading Co Ltd, 750 Third Ave, New York 17.

—E P Winch
Manager, Transformer Sales
English Electric Canada

In Defense of Humanities

To the Editor:

Mr Keyes' letter (Oct 31 p 28) which you very aptly entitled "Damn the Humanities, Full Speed Astern," shows that he either lacks knowledge of the humanities, himself, or lacks an intelligent comprehension of the lessons taught. Mr. Keyes omitted two important definitions which detract from the point he wants to make. He obviously deplores "liberals," and considers "political responsibility" the keynote of political motivation; but he neglects to define these terms. His readers may give him credit or discredit according to what they think he means, I assume he uses these terms in the narrowest sense.

Current inflection has given the word "liberal" as applied to politics the connotation of "left-wing." A true political liberal, however, is not so tethered to party-line politics that he can no longer think and act as his own moral conscience directs him. This definition is independent of political affiliation. I

wonder if Mr Keyes' definition is similarly independent. As to "political responsibility," it can mean what anyone wants it to mean.

The following poem describes my impression of the trait of a mind which makes it effective wherever problems must be considered. I entitled it "Intellectual Responsibility" in antithesis to Mr Keyes' apparent concept of "political responsibility."

Intellectual Responsibility

We love to learn, and learn to love
The knowledge we have gained.
We live in fear, and fear to live
With knowledge unattained.
To think we know's to know to think
And search for added facts.
A deed thus done's to do a deed
That intelligence enacts.

Unfortunately, Mr Keyes is right in stating, "People do not act on facts alone." But those who try to act on facts rather than tradition, habit, inertia or a misguided sense of political responsibility can be thanked for the present stability in the two-party system. It might be convenient if everyone agreed with me, or with Mr Keyes; but how long would it take, then, before we all forgot how to think. I hope Mr Keyes' frustration at opposing views is not greater than his belief in democracy.

—F SEIDEN
Sperry Gyroscope Co
Syosset, N Y

Editors Note: A reader would like to dispose of the following bound volumes (text and advertising) of PRODUCT ENGINEERING: 1935 and 1943 through 1956. Anyone interested in obtaining these volumes, write: Reader to Editor, PRODUCT ENGINEERING, 330 W 42nd St., New York 36.

COMING EVENTS

DECEMBER

27 . . . . American Astronautical Society, Lunar Flight Symposium, Biltmore Hotel, NYC

26-31 . . . . American Association for the Advancement of Science, NYC

JANUARY

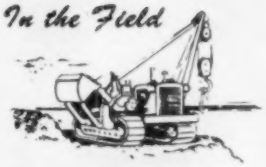
9-11 . . . . Institute of Radio Engineers jointly with AIEE, ASQC & EIA, 7th National Symposium on Reliability and Quality Control, Bellevue-Stratford Hotel, Philadelphia.

9-13 . . . . Society of Automotive Engineers, International Congress & Exposition, Cobb Hall, Detroit

16-19 . . . . Instrument Society of America, Winter Conference & Exhibit, St. Louis

For a current listing of addresses of societies and associations send 25¢ to PRODUCT ENGINEERING Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R32.

In the Field



On the Road

In the Shop

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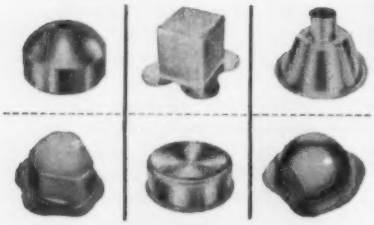

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These are just a few of the things you may get for Christmas.

The prices? A mere 89¢ for the lighter-flashlight; $4.98 for the backscratcher; $6.40 for the tooth-polisher; $11 for the screwdrivers; $19.95 for the welcome mat, and also for the home polisher and for the sharpener; and a round $100 for the scale (your choice of metallic or wood finishes).

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Here's a conversion calculator—a circular sliderule for literally dozens of volume, speed, weight, length, angle, pressure, and energy factors—now available from Science Materials Center, 59 Fourth Ave, New York 3. Just set the inner and outer scales in proper alignment (a letter and symbol system does the trick) and read off inch-centimeter, calorie-btu, watt-hp, gram-ounce or any one of nearly a hundred other equivalents. A table on the back gives the correct settings. Putting the small *d* opposite the big *h*, for instance, turns the dial into an inch-to-centimeter converter. The multiplication factors are also given so you can do your own figuring, if you wish. Price $1.95.

(Note to boating fans: the gadget will even convert knots to miles per hour.)

Now: reinforced sponges

The newest "reinforced plastics" for home use are mesh-strengthened cellulose sponges; and, surprisingly, the mesh is cotton. The reason: cotton fiber has radiating fibrils that interlock with the cellulose. DuPont is making the sponge, marketing it nationally at a suggested retail price of 39¢. Size: 7½ x 10 in. —ARG

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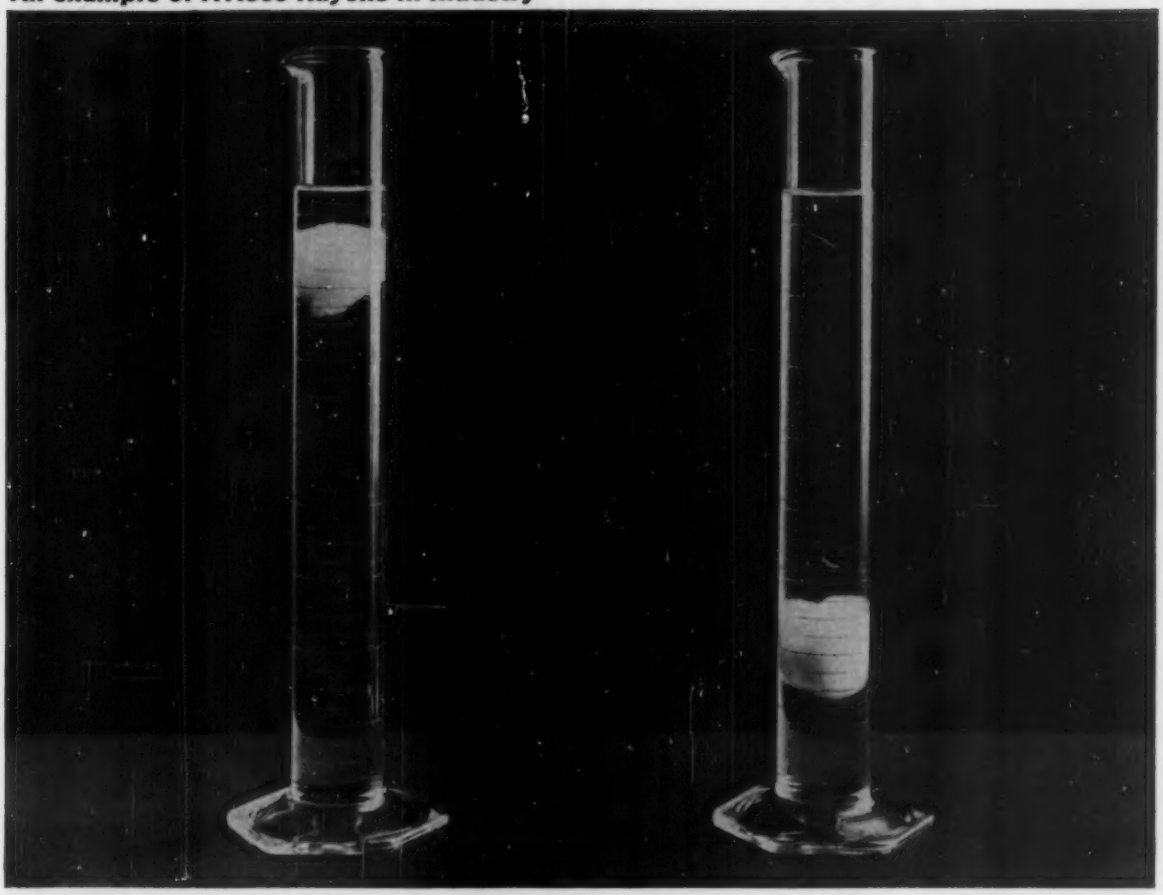

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PRODUCT ENGINEERING HORIZONS

DECEMBER, 19, 1960

MORASS OF INDECISION

Once, some years ago, someone told me of a study made by AT&T to determine the superior qualities of executives. The major one turned out to be the ability to make correct decisions. In this characteristic, the figures (as I remember them) were 59% correct decisions for subordinates, 60.5% for executives—a rather small but apparently important margin.

I say "as I remember them," because none of the current AT&T generation can locate or identify the study in question. It could prove to be interesting, particularly if it were possible to compare executives of the time when it was made with the current crop.

I suggest this because it seems to me that fewer men are decisive in our modern world. There are three possible causes: decisions more difficult to make, less "command" authority in management, greater conservatism in large organizations.

Decisions at lower levels tend to be simple and to deal with relatively uncomplicated problems. But in the high echelons, the problems are no longer clear-cut and they tend to become involved with people and opinions. So the decisions are harder to make, and there's less assurance that they will be right. This is true even if the decider has considerable experience—in fact his experience may give him a wrong answer.

Perhaps this is one explanation of the trend to younger executives. But perhaps there is also another. The younger man tends to make quick decisions. A higher percentage may be wrong as a result, but at least a decision is made. We oldsters tend to temporize and reflect, thus delaying the decision. In some instances, we delay long enough that the decision becomes unnecessary or circumstances make the correct decision obvious. These are advantages. But in other instances, priceless opportunities are lost because somebody couldn't make up his mind.

Secondly, present-day decisions usually involve much more money, and that money belongs to other people, so the executive must be more careful of decisions that involve it. The decisions are farther-reaching, too—they affect more people for a longer period of time.

Thirdly, there's the matter of size and resulting conservatism. In the typical large corporation, only the top man can make the "yes" decisions essential for progress; his subordinates can only say "no." This accounts for the efforts of outside creative people to bypass all departments and individuals below the top—they're trying to avoid the highly probable "no." It also accounts for the inside engineering executives and engineers who have similar troubles; they must take a new idea right to the top.

In many organizations, the situation is even worse than that. There is no clear-cut policy, no plan, no program—nobody has been brave enough to make the necessary decisions.

Decision-making is soul-searching and unrewarding work. Personal safety suggests that decisions be postponed or avoided by any possible means, for fear they may be wrong. But the man who goes to the top usually has the peculiarity that he makes up his mind. Even if he's wrong part of the time, something gets done and everyone knows where he stands. He isn't wallowing in the Morass of Indecision.

R. T. Langeman

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PRODUCT ENGINEERING

How to select

ELECTROMAGNETIC CLUTCHES and BRAKES for AUTOMATIC CONTROL

Confused by the rapid growth in this field? Here's design information on the three major types—with sketches of 10 designs and 12 applications—to help you make the right choice.

JOHN S PROCTOR, *design consultant*

Until recently there was little choice for the product designer who needed a control in the form of a miniature electromagnetic clutch or brake—and wanted it to be of industrial or commercial grade. But now, many manufacturers who had previously specialized in high-precision, high-cost, custom-engineered components for the military are seeking broader markets. They have begun to develop large product lines—including magnetic-friction, magnetic-particle, pure-magnetic and specialty types—for general industrial use.

The result of this rapid growth has been a certain amount of mutual misunderstanding. Manufacturers of magnetic clutches and brakes have not been able to tell the designer what they have to offer, so engineers shopping for magnetic clutches and brakes have not been able to tell the supplier what they need.

Some confusion is inevitable, of course, in such an expanding market, where new products must be introduced piecemeal, before adequate catalogs and design literature can be compiled. A good bit of this will be cleared up when more comprehensive catalogs are published. (Several big ones are scheduled for release in the next few months.) But in the meantime, this rundown of the major designs will bring you up to date.

WHEN IS IT "CONTROL"?

One barrier to an effective survey of this field is the lack of realistic industrial standards among the suppliers. For example, there is no substantial agreement on the point at which the "control" field ends and "power" applications start. PRODUCT ENGINEERING queried a number of manufacturers recently, and received estimates ranging from a few lb-in. (2 in. dia) to 700 lb-ft. So for the purposes of this article, we have defined a "control" clutch as one measuring not much more than 2 in. dia, with a maximum torque capacity on the order of 5 lb-in.

MAGNETIC FRICTION CLUTCHES

The most common type of electromagnetic control clutch—the simplest and most adaptable—is the magnetic friction clutch. It works on the same principle as a simple solenoid-operated electric relay with a spring return to normal. Like the relay, it is a straightforward automatic switch for controlling the flow of power (in this case, torque) through a circuit. Most manufacturers stock a variety of basic types, designed to consume a minimum of electric power in any particular application. Ten of these are tabulated on page 30, and a dozen typical applications for them are sketched on page 32.

Note that each normally coupled single-coil design is followed by the corresponding normally uncoupled type. Product lines are set up this way to benefit the engineer. If, in your proposed duty cycle, shafts are to be coupled for longer periods of time than they are uncoupled, you can select a normally clutched type to save power and reduce heat.

Basic model variations

Most of the basic clutch and brake types illustrated schematically in the table are available in a number of configurations. It is here that comparisons grow tricky, and delicate compromises must be made. Once you have found the functional clutch design you need, you must then select the right combination of coils, the shafts, the clutch faces.

This does not necessarily involve comparisons of the products of competing suppliers—many companies offer a wide choice of alternative features in their standard lines.

Rotating or fixed field?

This is a question primarily of magnetic design. Rotating-field clutches employ a rotating coil, energized through

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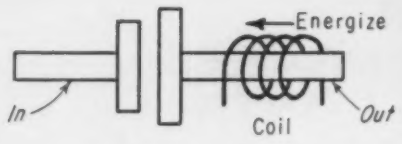
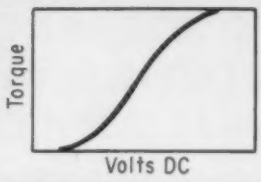
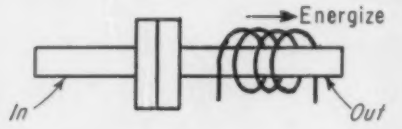
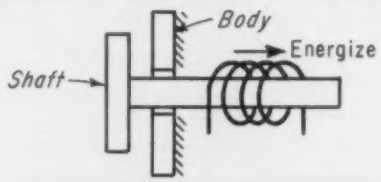
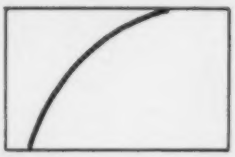
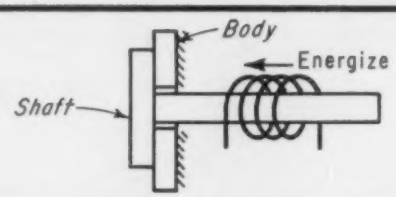
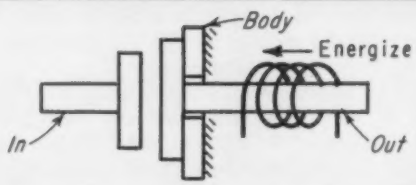
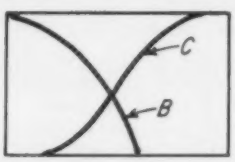
REPRINTED—Circle P73, inside back cover

TYPES OF MAGNETIC FRICTION CLUTCHES

SCHEMATIC	TYPICAL PERFORMANCE CURVE	DESCRIPTION
		**SIMPLE CLUTCH** Normal: Both shafts free Energized: Shafts clutched
		**SIMPLE CLUTCH** Normal: Shafts clutched (by spring) Energized: Shafts free
		**SIMPLE BRAKE** Normal: Shaft free Energized: Shaft braked to body
		**SIMPLE BRAKE** Normal: Braked Energized: Free
		**CLUTCH BRAKE** Normal: Input free, Output braked to body Energized: Input clutched to output

brushes and slip rings. Fixed-field units have a stationary coil. Rotating-field units are still the more common, but there has been marked trend toward the fixed-field design.

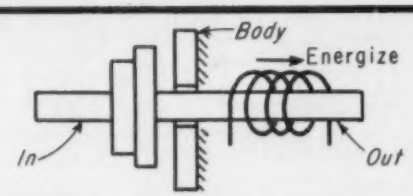
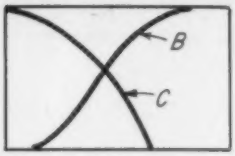
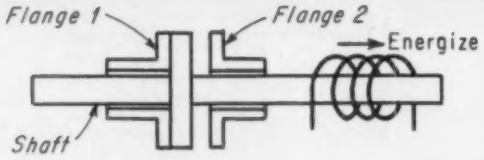
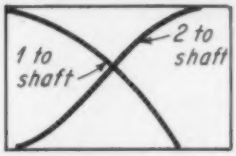
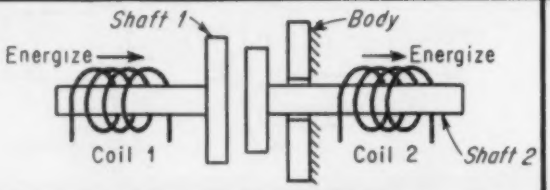
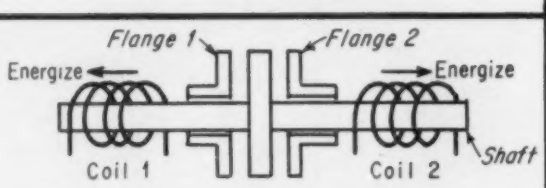
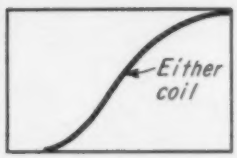
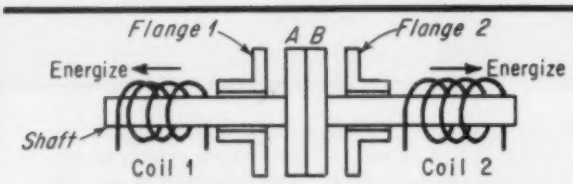
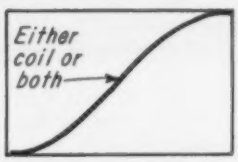
Generally speaking, a rotating-field clutch is a two-member unit, with the coil carried in the driving (input) member. It can be mounted directly on a motor or speed-reducer shaft without loading down the driving motor. In the smaller sizes, it offers a better ratio of size to rated output than the fixed-field type, although the rotating coil increases inertia in the larger models.

A fixed-field clutch, on the other hand, is a three-member unit, with rotating input and output members and a stationary coil housing. It eliminates the need for brushes and slip rings, but it demands additional bearing supports, and may require close tolerances in mounting. It also requires conducting the magnetic circuit through at least two extra airgaps, which lowers comparable efficiencies and increases drag in a given size and design. On the other hand, this type offers superior resistance to humidity, corrosive atmosphere, and other rugged environmental factors, but is generally more expensive.

Through-shaft or coupling type?

The input and output members of a through-shaft clutch are arranged on a common shaft, which runs the length of the unit, and extends at one end, or at both. One member idles on bearings and is driven from a countershaft through gears, sprockets or pulleys. The other member is secured to the common shaft. This type, on the whole, is more reliable, especially in large sizes.

The coupling type of clutch has separate input and output shafts, each with its own coupling member. (The output member is generally smaller than the input.) Even a slight misalignment can reduce clutch torque and pro-

SCHEMATIC	TYPICAL PERFORMANCE CURVE	DESCRIPTION
		**CLUTCH BRAKE** Normal: Input clutched to output Energized: Output braked to body, input free
		**DUPLEX CLUTCH** Normal: Flange 1 clutched to shaft, flange 2 free Energized: Flange 2 clutched to shaft, flange 1 free
		**DOUBLE-COIL CLUTCH-BRAKE** Normal: Both shafts run free Coil 1 Energized: Shaft 1 clutched to shaft 2 Coil 2 Energized: Shaft 1 free, shaft 2 braked Both Coils Energized: Both shafts braked
		**DOUBLE-COIL DUPLEX CLUTCH** Normal: Shaft and both flanges run free Coil 1 Energized: Flange 1 clutched to shaft, flange 2 free Coil 2 Energized: Flange 1 free, flange 2 clutched to shaft
		**DOUBLE-COIL TRIPLEX CLUTCH** Normal: Shaft and both flanges run free Coil 1 Energized: Flange 1 clutched to shaft at "A", flange 2 free Coil 2 Energized: Flange 1 free, flange 2 clutched to shaft at "B" Both Coils Energized: Both flanges clutched to shaft

duce heating and wear. Because the individual members are cantilevered on the shaft ends, there may be a question of adequate bearing support.

Double-end or coaxial shafts?

Single-end units with coaxial input and output shafts are generally more precise than those with shafts at opposite ends. But the price for this is higher precision in manufacture. You must decide whether—in your application—the advantage gained is worth the extra cost.

What kind of clutch face?

When specifying the type of clutch face you need, consider costs and weigh advantages and disadvantages.

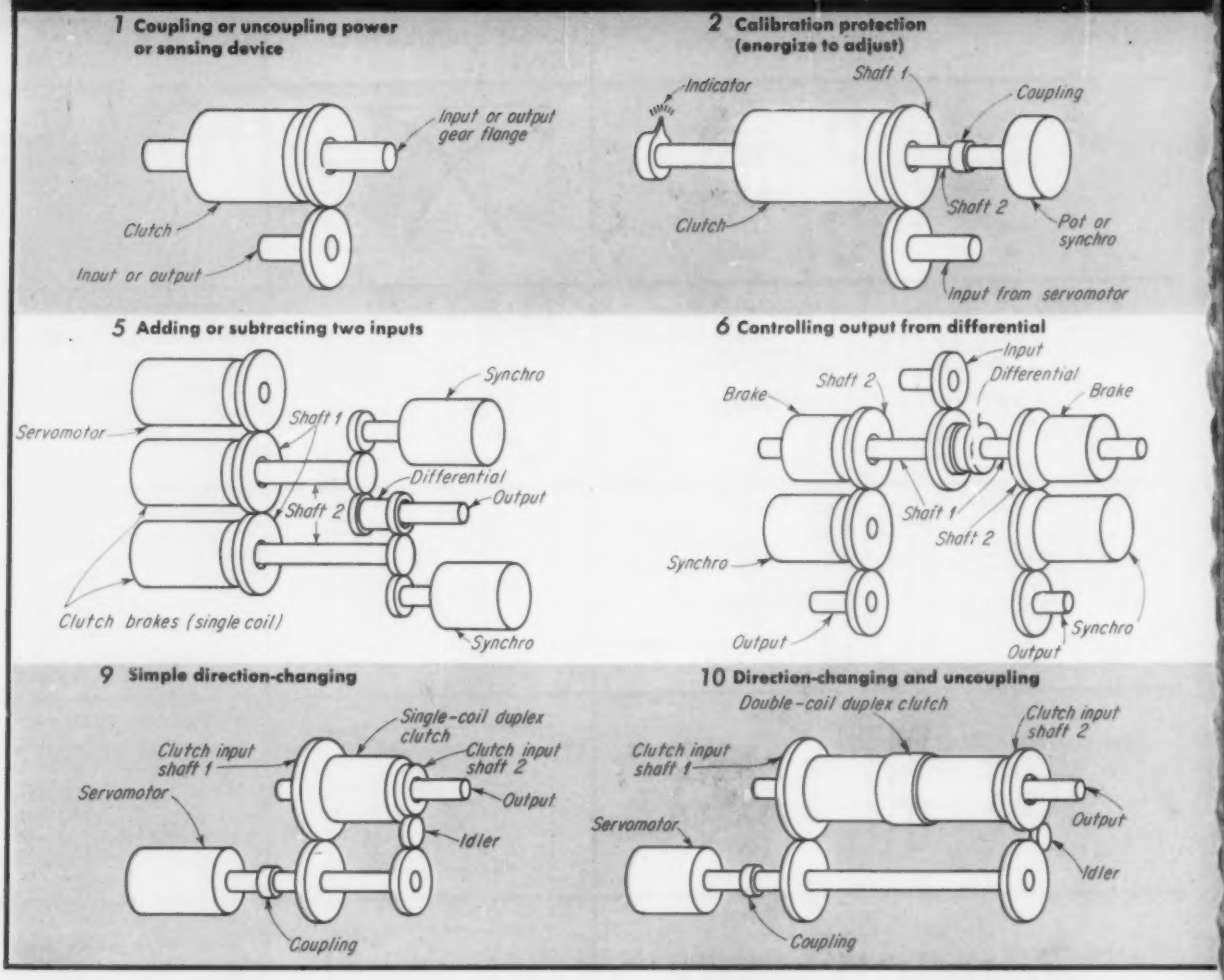
Soft metal faces are inexpensive and may prove serviceable in undemanding applications. They tend to break down under heavy duty, creating abrasive particles that reduce torque and may eventually ruin bearings.

Unplated magnet iron offers the best torque characteristics, but corrosion will upset them. Iron is frequently chrome-plated to resist corrosion and wear. If the chrome is thick enough to protect the iron, it cuts down the torque; if it is thin, it can chip.

Composition friction faces usually give relatively short wear life, slip when wet or oily, harden and glaze or burn when overheated, and may be attacked by fungus.

Crown and jaw tooth faces offer a positive lock that is unaffected by oil or water. (They are really closer to being couplings than true clutches.) Some models can develop torques 400% higher than comparable smooth-face types. One disadvantage is that they can be engaged properly only when the meshing teeth are perfectly aligned. Actu-

12 TYPICAL APPLICATIONS FOR ELECTROMAGNETIC CLUTCHES



ation at speed can damage them severely, or even strip them. Even the more expensive models, specially hardened to withstand abuse, are not recommended for applications where they may be used at speeds above 300 rpm.

PURELY MAGNETIC CLUTCHES

Probably less familiar than the friction types are hysteresis and eddy-current clutches, which operate on straight magnetic principles and do not depend upon mechanical contact between their members. The two styles are almost identical in construction, but the magnetic segments of the hysteresis clutch are electrically isolated and those of the eddy-current type are interconnected. The magnetic analogy of both styles is similar in that the flux path is passed between the two clutch members.

Hysteresis clutches

The hysteresis clutch is a proportional-torque control device which—as its name implies—exploits the hysteresis effect in a permanent-magnet rotor ring to produce a substantially constant torque that is almost completely independent of speed (except for slight, unavoidable secondary eddy-current torques—which do not seriously reduce performance). It is capable of synchronous driving or continuous slip, with almost no torque variation at any slip differential for a given control current. Control-power requirement is small enough for vacuum-tube drive. Typical applications include wire or tape tensioning, servo-control actuation, and torque control in dynamometers.

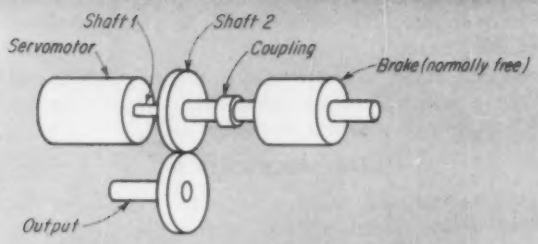
Eddy-current clutches

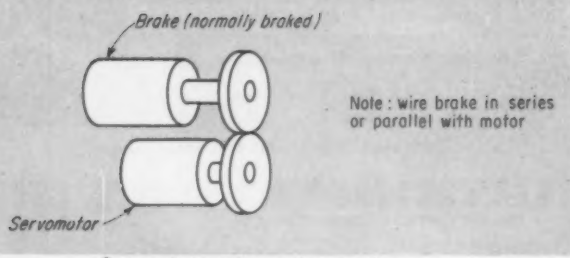
Eddy-current clutches, on the other hand, are inherently speed-sensitive devices. They exhibit virtually no hysteresis, and develop torque by dissipating eddy currents through the electrical resistance of the rotor ring. This torque is almost a linear function of slip speed. These clutches are best used in speed-control applications, and as oscillation dampers.

PARTICLE AND FLUID MAGNETIC CLUTCHES

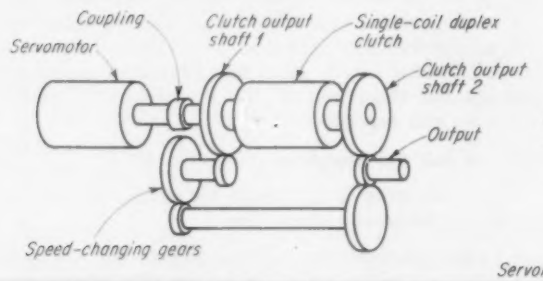
There is no real difference between magnetic-particle and magnetic-fluid clutches, except that the magnetic medium in the first is a dry powder and in the second it is a similar powder—but suspended in oil. In either type, the

3 & 4 Simple servomotor brakes

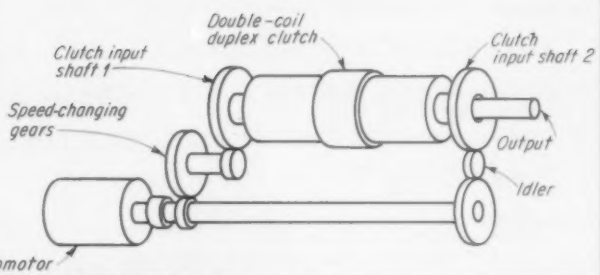




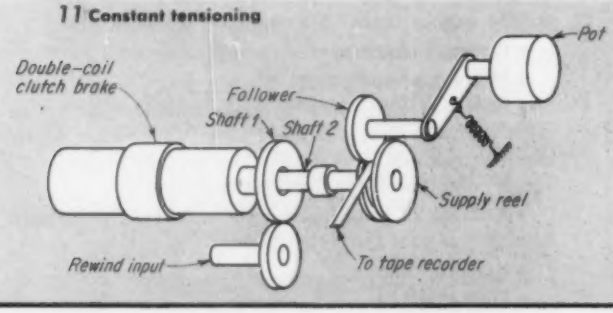
7 Simple speed-changing



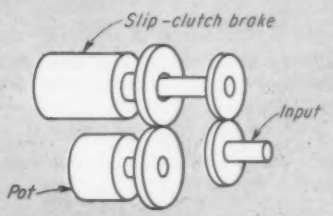
8 Speed-changing and uncoupling



11 Constant tensioning



12 Potentiometer control



Normal: input drives pot, with slip protection
Energized: input disconnected and pot locked

ferromagnetic medium is introduced into the airgap between the input and output faces, which do not actually contact one another. When the clutch coil is energized, the particles are excited in the magnetic field between the faces; as they shear against each other, they produce a drag torque between the clutch members.

Theoretically, these clutches can approach the proportional control characteristics of a hysteresis clutch within the small weight and size limits of a comparably rated miniature friction clutch. But in practice the service life of miniature magnetic-particle clutches has so far been too short for industrial usage. Striking advances, which promise to improve their life and wear characteristics and general reliability, have been made in recent months, but foolproof clutches are not yet available in quantity at competitive prices.

OTHER MAGNETIC CLUTCHES

Two sophisticated concepts—neither of them yet developed to the point of practical application—may prove of great academic interest to anyone researching this field.

Electrostatic clutches, which use high voltages instead of magnetic field to create force-producing suspensions.

Magnetostrictive clutches using a magnetic force to change the dimenisons of a crystal or metal bar poised between two extremely precise faces.

FACTORS THAT AFFECT DESIGN

When you design magnetic clutches into a control system, remember to pay close attention to torque, total inertia (WR^2) and heat dissipation. Simple formulas for computing these variables are given on page 34. Here are some more factors to consider.

Response time of friction clutches

Some precision units offer response on the order of three microseconds, with a proper supply voltage. If you don't need such speed, use a less expensive clutch.

Response time is affected by both electrical and mechanical factors—electrical, because of coil inductance, and mechanical, because of width of magnetic airgap and tension in return spring. (An article is now in preparation defining response time and telling how to control these electrical and mechanical factors.)

CALCULATIONS YOU WILL NEED

INERTIA (WR^2)

Inertia requirements for these devices are generally given in terms of WR^2 (moment of inertia), where W = weight and R = radius of gyration). Compute total WR^2 for all bodies in the load. If bodies do not operate at clutch or brake speed, use the following formula to compensate:

$$WR^2_{equ} = WR^2_a \left(\frac{rpm_a}{rpm_c}\right)^2$$

WR^2_{equ} = Equivalent WR^2 at clutch or brake speed, (lb-ft²)
WR^2_a = Actual WR^2 of body
rpm_a = Speed of body
rpm_c = Speed of clutch or brake

TORQUE

This basic rating can be based on either of two considerations:

A Horsepower and speed:

$$\text{Torque (lb-ft)} = \frac{hp \times 5250}{rpm} \times \text{safety factor}$$

(safety factor usually ranges from 1.5 to 5, increasing with severity of duty cycle)

B Time and speed:

$$\text{Torque} = \frac{WR^2 \times \Delta\ rpm}{308t}$$

Δ rpm = (initial rpm (lb-ft²) − final rpm)
WR^2 = total inertia of load (lb-ft²)
t = required starting or stopping time (sec)

(Torque here is average torque, in lb-ft, to accelerate or decelerate load. *This torque is in addition to that needed to overcome friction and other load forces.*)

HEAT DISSIPATION

If a clutch or brake cannot dissipate the heat generated by slip, it will overheat and wear out. Calculate heat as follows:

$E = 0.00017 \times WR^2 \times \Delta\ rpm^2 \times f$
E = Energy in (lb-ft/min)
WR^2 = total for all parts stopped or started
$\Delta\ rpm^2$ = (initial rpm² − final rpm²)
f = number starts and stops/min.

Location of clutch

Where to locate the clutch in a system is generally dictated by the system itself, but you may have some choice as to whether it should be installed on the high or the low side of a speed reducer.

The chief virtue in putting a clutch on the high-speed side is that is reduces the torque requirements, therefore a smaller model may be used.

It is usually advantageous to use a larger, cheaper clutch on the low-speed side instead. Because of its size, the large unit will dissipate heat more efficiently. If the step-down in speed is from the motor to the load, the various elements between the motor and the clutch (reducer, sheave, gear, and so on) will not have to be accelerated and subjected to the shock of starting and stopping.

Five "don'ts"

These five negative rules will lead to positive results, if they are carefully observed.

- Don't specify small friction clutches for continual-slip applications. They can't take friction temperatures.
- Don't expect any friction clutch or brake to maintain its torque limits within ±100% over its entire life. (Realistic figures may run as high as +400 −100.)
- Don't expect instantaneous response. (Consider switching time and magnetic-field buildup.)
- Don't expect full torque at initial engagement. (This depends on speed differential between the clutch members, and other factors.)
- Don't expect to instal a clutch and forget it, as you might a sealed electronic component. (Most clutches require periodic overhaul and adjustment.)

FINAL SPECIFICATION

When you have made a tentative selection of the clutch design needed, tell the supplier your entire problem—don't just notify him of your solution. Describe your proposed application in detail and he may be able to recommend some still-uncataloged off-the-shelf item that will do the job more neatly than a special order, and at a fraction of the cost. Better still, he may come up with a suggestion that will save you a bitter disappointment. Ordering strictly by part number from an out-of-date list can cheat you of the manufacturer's special knowledge and experience.

What to tell the suppliers

When you write to a supplier for advice, be sure to specify the following information:

- Torque requirements. (Don't forget that a clutch or a brake is a torque device. Engineers all-too-frequently specify only in terms of horsepower, ignoring speed.)
- Proposed clutch rpm
- Motor type and ratings
- Inertia of load, with particular consideration for all parts that will exert a flywheel effect. (For most manufacturers, give this figure in oz-in.², rather than in oz-in.-sec², slug-ft², and other unconventional units.)
- A sketch of your application, and a brief description of what you want the clutch to do
- Response time
- Duty cycle
- Environment
- Power available

Acknowledgements

Many suppliers of components assisted in the preparation of this article. Our special thanks go to John E. Traise of Magtrol Inc, Buffalo, NY, for background information and Autotronics Inc, Florissant, Mo, for the application illustrations. We also wish to thank the following companies for their technical assistance:

Dial Products Co, Bayonne, NJ
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Hurst Mfg Corp, Princeton, Ind
Instrument Components Inc, Div of Belock Instrument Corp, College Point 56, NY
Kearfott Div, General Precision Inc, Clifton, NJ
Pic Design Corp, subsidiary of Benrus Watch Co Inc, East Rockaway, NY
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Simplatrol Products Corp, Worcester, Mass
Technology Instrument Corp, Acton, Mass
Warner Electric Brake & Clutch Co, Beloit, Wis

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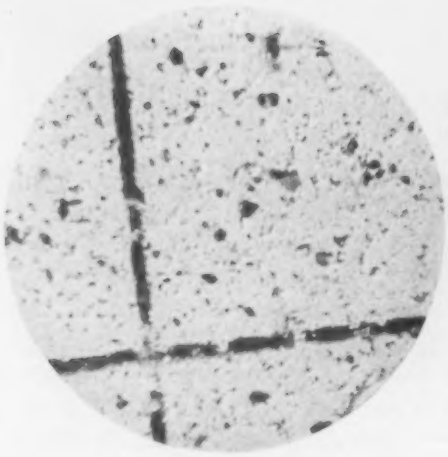


See cover for this in full color.

new criteria for MEASURING FLUID CONTAMINATION

It's no snap to measure and count dirt particles smaller than 40 microns in hydraulic fluids. Yet such data are often essential. Here are latest available measurement techniques.

FRANK YEAPLE
Associate editor

Lord Kelvin said that if you can't measure something and express it in numbers, then you don't have full knowledge of it. But this isn't always easy. The measurement of contaminant particles in a fluid is a good example: counting and measuring them seems more an art than a science, particularly in the microscopic sizes.

Scientific work on contaminant analysis is being done, however, because many modern fluid-control devices cannot tolerate dirt. And where system specifications call for extremely clean systems, ways are being found to monitor them before and during service. The need for such care was pointed out in a recent article (*PE—Nov 28 '60, p 29*). It showed that passing fluid through an absolute 10-micron filter doesn't necessarily ensure freedom from 10-micron-and-over particles in an over-all system—there are other sources of dirt that filters can't reach until the system has recirculated awhile.

Dirt particles larger than 40 microns (1 micron = approx. 1/25,000 in.) are relatively easy to measure and remove. For one thing, they are visible to the naked eye. But some systems must be cleaner; some servovalves have less than 0.0002-in. (about 5 microns) clearance between operating parts, and require super-methods of cleaning and monitoring. Today's state of the art is at about the 5-micron level in absolute removal rating: particles 5-25 microns in size can be removed and measured with some consistency, but below 5 microns, only extremely rigorous measures will work.

HOW CLEAN IS CLEAN?

Clean fluid from an oil drum is too dirty for a missile servo system, yet is clean enough for an ordinary industrial control. Cleanliness therefore is relative.

Ordinary contamination by solids differs from "film" and "bacterial" types. Clean liquid-oxygen systems must be free of hydrocarbon films, but can tolerate some inorganic dirt. Hydraulic systems must be free of solids, but are not troubled by films. Surgically clean equipment can contain some dirt, so long as the dirt is sterilized!

The dirt particles

Particulate dirt—the type discussed in this article—is rarely uniform in shape. (The full-color photomicrograph on the cover of this issue is an example of actual filtered dirt.) Most particles are jagged and irregularly shaped, varying from submicron metal dust (worn from moving parts), to organic fibers several inches long. For comparision, the diameter of a red blood corpuscle is 5 micron; of bacteria, 1 micron; of human hair, 75 micron.

The method of dimensioning a particle differs with the purpose. Smallest dimension of a fiber should be given if its tendency to pass through a surface-type filter is being evaluated. However, its longest dimension is more important when evaluating fluid contamination downstream of the filter, because the long dimension may easily bridge and block an orifice or clearance space.

Sources of contamination are virtually impossible to list because there are thousands. Common ones are: lubricants used on pipe fittings; atmospheric dust of almost any material; metal scraped off one or both surfaces of mating or moving parts; metal scraped off during making-up of fittings; particles from pumps and accumulators; elastomer seals; sand in castings; oxides; lint; oil additives that decompose or become gelatinous; bacterial growth in fluid or system; chemical action; paint; and residue from overheated oil.

It is not enough to say "clean" or even "superclean." You've got to say exactly how clean, of what, and where. Many users of extremely clean hydraulic fluids—the aircraft and missile industries are leaders in this area—have defined the limits in terms of their own specific needs.

Company standards

Douglas Aircraft's missiles division requires that a 100-milliliter sample of system fluid must not produce "background color" when filtered through an 0.8-micron, 47-

millimeter-dia cellulose membrane (made by Millipore Filter Corp, Bedford, Mass). Fewer than 10 particles over 40 microns are allowed. A fluid so pure is termed "super-clean" by Douglas; extreme precautions are taken during manufacture, assembly, test, and operation at frequent intervals.

Government-specification fluids such as petroleum MIL-H-5606A already have strict quality control during manufacture, including a required passage through 10-micron filters before packaging in containers. For special applications some users (government agencies) get even closer control by specifying a random sampling of the oil. Here is one example, for quart and gallon cans:

- Take as many 100-milliliter test samples as the cube root of number of containers filled in one day.
- Total of particles over 100 microns in size to be less than number of samples.
- Filtration time for each 100-ml sample to be less than 50 minutes.
- Weight of sediment from any 100-ml sample not to exceed 3.0 mg.

Some users have suggested including a detailed count of particles in the sampling of MIL-H-5606A petroleum fluids. The suggested limits (not yet a standard) are:

Particle-size range, microns	5-15	16-25	26-50	51-100
Max number allowed in 100-ml sample	20,000	9000	2500	150

These counts are actually higher (in 25-100 micron range) than some users already allow. For example, in-the-factory standards set by The Martin Co for airborne and ground operational equipment require the following contamination limits to be met for MIL-H-5606A and 6083B fluids:

Particle-size range, microns	0-25	25-100	over 100
Max number allowed in a 100-ml sample	unlimited	250	10

STANDARDS OF MEASUREMENT

It is not enough to specify cleanliness; you must also specify the way to measure it. All standards and methods of contaminant-particle measurement are based on particle count and size in a given volume of fluid.

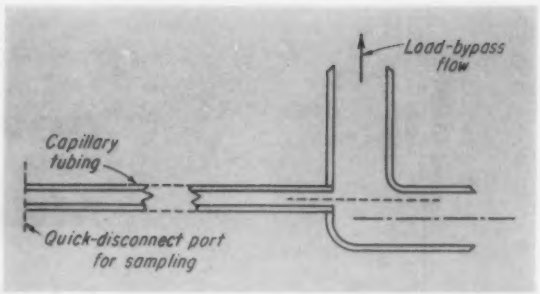
Sampling-type methods require a sample of fluid to be taken, then passed through a special filter to collect all particles for examination.

Onstream-type methods count particles in a given size range as they flow through the actual system.

No method is completely satisfactory, but the most accepted one is sampling-type technique ARP 598 developed by SAE (Society of Automotive Engineers).

Ruled-membrane sampling (ARP 598)

Aeronautical Recommended Practice ARP 598 issued by SAE specifies filtering a 100-ml sample of fluid through a membrane of cellulose nitrate. The membrane is ruled as a grid, with 100 equal squares covering the entire effective area. All particles can be counted, or just those particles in a representative (random) number of squares. The random count can be extrapolated to represent all the squares. (A microscope is needed to make the count.)



SAMPLING ELBOW designed by Douglas Aircraft has offset capillary outlet and gives free path from oil stream to sample bottle via quick-disconnect valve. Offset outlet extracts fluid at point halfway from centerline to pipewall.

The general acceptance of ARP 598 as a standard is based partly on its carefully detailed instructions regarding cleaning apparatus, transferring of samples, filtration, examination, microscopic equipment, lighting techniques, and resolution. Tests can be duplicated reasonably well by different operators. And it is a self-checking procedure: the slide is viewed by more than one lab. Standard calibrated slides are available, and both operator and equipment can be checked with standard method.

Accuracy in particle count of plus or minus 20% may be expected when using ARP 598, if the operator is highly qualified. This estimate is based on an interesting series of "round-robin" tests sponsored by Marshall Space Flight Center (formerly Redstone Arsenal) in Huntsville, Ala. The tests were made this way:

- Three Millipore Corp membrane disks containing varying degrees of particulate contamination were sealed between glass plates. Each of these slides was examined independently by 10 companies: 4 filter manufacturers, 3 missile manufacturers, 2 servovalve manufacturers, and a research institute.
- Each company followed counting procedure in ARP 598 as rigorously as possible. Some already had experience in using the technique.
- The average count was calculated, and deviation plotted from this average.

Results showed that although some inexperienced operators disagreed considerably in total particle count (as much as 50% based on an established average), the qualified operators were able to count consistently close, within 20% deviation from the average. However, some system designers do not think the 20% figure is realistic, and would choose a much higher one.

Other membrane-type tests

Filter-disk tests are as old as chemical knowledge. The fluid passes through, and the residue is weighed (gravimetric method); counted; or just looked at (patch background color). Any of these tests may be used in evaluating fluid contamination.

Gravimetric tests simply weigh a membrane that starts out clean and dry (heated and dessicated) and then weigh it again after it has filtered a given volume of contaminated

Checklist—Evaluating a Particle Counter

- √ Will it distinguish dirt particles from air bubbles?
- √ Will it detect transparent particles?
- √ What particle dimensions are measured (volume, cross-section area, surface area, random length)?
- √ Can it distinguish between two adjacent particles?
- √ What about small particles near large particles?
- √ Are results reproducible throughout expected range of contaminant sizes?
- √ How do results compare with ARP 598 over entire concentration range?
- √ What is saturation point (where there too many particles to count accurately in each size range)?

test fluid. If desired, the weight of noncombustible residue can be found by burning filter in special oven.

Counting-type tests are usually similar to ARP 598, and differ only in ways the sample is gotten, the volume of the sample, and in how it is forced or allowed to pass through the membrane. In the end, you simply count the particles retained by the membrane.

Color-background tests use visual experience of the operator to compare a discolored test filter with a non-contaminated new filter. With practice, over-all particle count can be estimated closely.

Getting the sample

Perhaps the most difficult part of sample-testing is getting the sample. It can be obtained as simply (and sometimes futilely) as dipping a cup of oil from an open tank; or by way of elaborate bypass piping with special fittings. Remember: a sampling valve might generate more dirt than you are trying to measure. (One suitable valve to use is ball-type with teflon seat.)

It is desirable to pick off the sample from a representative portion of the stream. But a simple pipe tee is not always the answer, because larger particles may not make the turn successfully. Inline takeoff (the sampling pipe concentric with the main pipe) is complicated, and might interfere with normal flow. Compromise is the sampling elbow-fitting designed by Douglas Aircraft (facing page).

AUTOMATIC PARTICLE-COUNTERS

Automatic devices are available that count particles in a sample (on a filter slide, or in a fixed chamber), or onstream. Of the six best-known types, three count from samples, and three onstream.

Sample-counter types

One of these is the Coulter counter, made by Coulter Electronics Inc, Chicago. It draws a sample of contaminated fluid (fluid must be made electrolytic) through a very narrow passage. Each particle that goes by displaces some of the liquid. This changes effective electrical resistance between two electrodes in the passage. Measurement of resistance gives indication of particle size, and a counter keeps track of total number passing through.

For counting particles on slides, there is the Cintel Flying-spot Particle Resolver, made by Rank Cintel Ltd, London. It is an optical system combined with a cathode tube and related circuitry. A moving spot of light scans the specimen (particles on the slide) and registers on the cathode tube via a microscope. Visual resolution is about 0.1 micron, and the device will count or measure contaminant particles as small as 1.0 micron.

Another counter for slides is the Casella Automatic Particle Counter and Sizer, made by Casella Electronics Ltd, London. It is an optical system combined with a photocell and related circuitry. The illuminated specimen slide is made to oscillate back and forth under the objective of a microscope, and contaminant particles on the slide interrupt a narrow beam of light created by an adjustable slit within the optical system. Photocell senses number and size of particles.

Onstream-type counters

These are similar to counters for fixed chambers, but can be connected directly into actual system.

One available device is the HIAC Automatic Particle Counter and Sizer (for liquids) made by High Accuracy Products Corporation, Claremont, Calif. It is connected into the line, and flow is forced to reverse within the device, creating turbulence. A small amount of liquid is continuously bled from the most turbulent point and is channeled through a narrow passage between a light source and a photocell. Particles (passing only one at a time under all normal conditions) are counted at the photocell. Total bled volume is captured in a graduated container, so that particles per unit volume can be calculated. Sensitivity can be adjusted to count particles above any given size within a 5 to 250-micron range.

Another available onstream-type counter (for air) is made by Royco Instruments Inc, Mountain View, Calif. It works on the same general principles as the HIAC—particles pass between a light source and a photocell.

An ultrasonic counter (for liquids) has been designed and built by Sperry Products Company under contract to Marshall Space Flight Center and now is undergoing evaluation tests at the Marshall laboratories. A transducer produces sound waves which pass through the liquid in a restricted portion of the flow. Sound waves reflected by particles back to the transducer are electronically detected, sized, and counted. Sensitivity can be adjusted for each of the four size ranges, detecting particles as small as 10 microns. Flow rate is small—about 0.1 to 1 gpm—through cell of present design, but bypass flow (in parallel with main stream) can be used. Instrument will be capable of continuous indication in fully closed and operating hydraulic system and will be adaptable to automatic operation.

ACKNOWLEDGMENT

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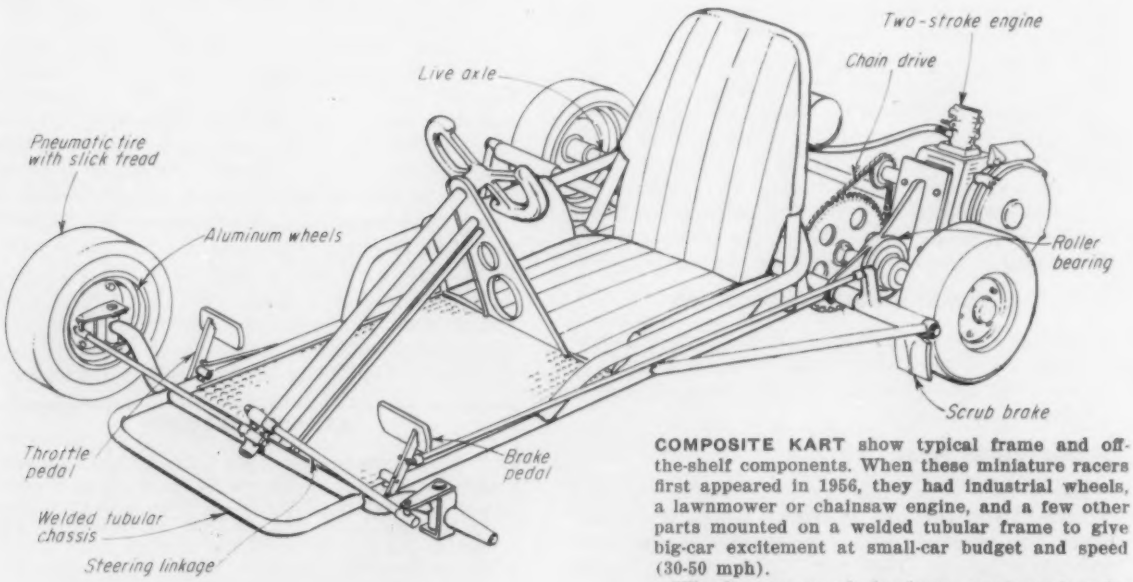
EDITOR'S NOTE: A previous article—"Selecting Filter Media," Nov 28, p 29—describes and evaluates every known type of media.

PRODUCT DESIGNS

Engineered Karts Take Over

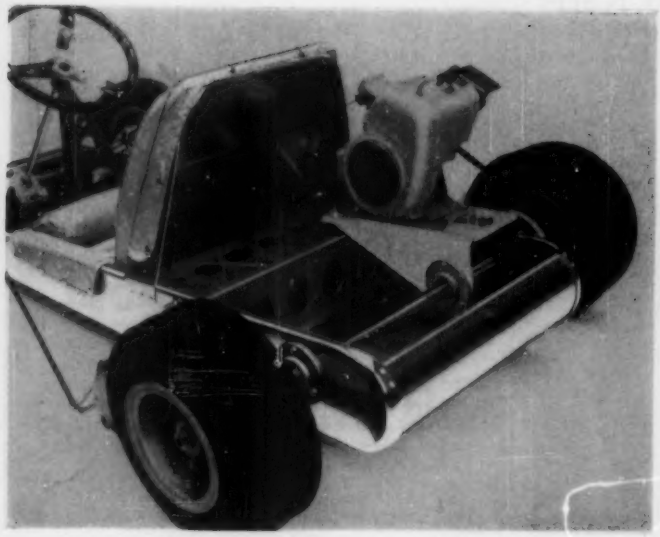
Four years ago, these tiny road-racers were merely pieced together from makeshift parts in home workshops. Then they caught on, and are now numbered in the hundreds of thousands. Result: Many manufacturers are providing engineered components, so addicts can buy sophisticated, "souped-up" models—in kits or off assembly lines. Here is a design look at typical components—which can also be a Christmas suggestion.



COMPOSITE KART show typical frame and off-the-shelf components. When these miniature racers first appeared in 1956, they had industrial wheels, a lawnmower or chainsaw engine, and a few other parts mounted on a welded tubular frame to give big-car excitement at small-car budget and speed (30-50 mph).

Wheels are now of aluminum or magnesium for lightness; tires are full pneumatic slicks for added traction on paved tracks; engines are hotter; brakes stop faster; wheel bearings are roller instead of plain.

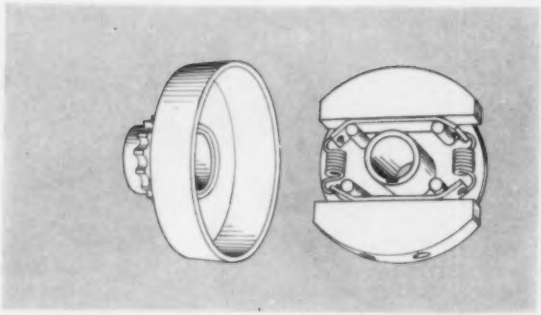
Specifications of a typical kart are: weight, 86 lb; wheelbase, 46 in.; front tread, 30½; rear tread, 34 in.; over-all length, 57 in.; front tires, 10 x 3.50 x 4 in.; rear, 12 x 4 x 6 in. Frame is 1½-in.-dia seamless steel tubing.



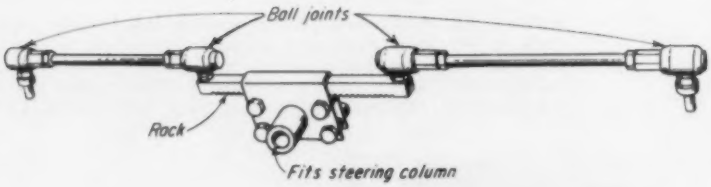
DOUBLE FRAME resembles ladder construction used by builders of big racing cars. Tubing is 1 in. dia instead of 1½ in. as in a single-tube frame. (McCulloch Corp, Los Angeles)

UNIT CONSTRUCTION eliminates tubes altogether. Use of riveted, stressed-aluminum sheet is similar to aircraft practice. (Jim Rathmann Enterprises, Inc, Miami)

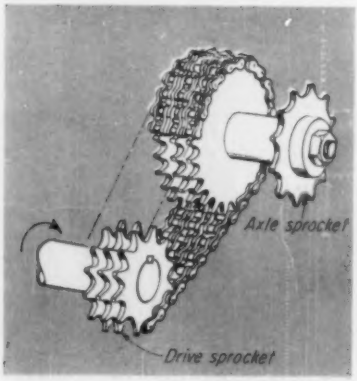
ACCESSORIES



CENTRIFUGAL CLUTCH allows using rope-pull starter on engines. Without clutch, karts must be pushed to start. With two engines, each driving one wheel independently, a clutch on each engine gives the effect of a limited-slip differential. The stronger the springs, the higher the engine speed at which clutch engages and disengages. This pin-cage clutch handles high torque at low speeds. Straight centrifugal type is better for high-rpm engines. Engine can lug—run at full throttle under load at low rpm—with pin-cage clutch because clutch disengages at a speed several hundred rpm lower than engagement speed. (Fairbanks-Morse, Magneto Div, Beloit, Wis)



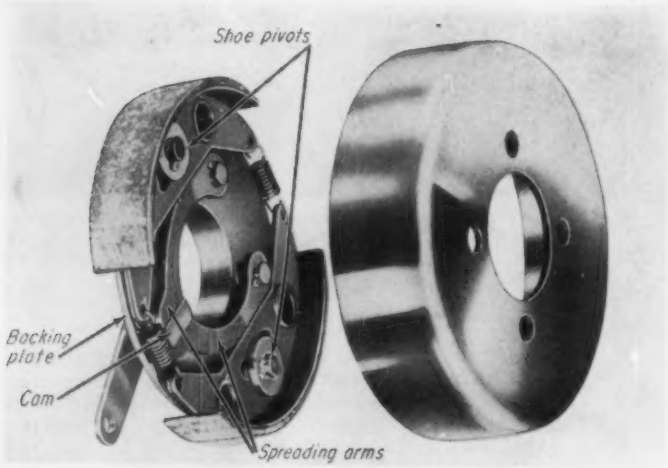
RACK-AND-PINION STEERING is positive; turns wheels at a constant rate. Usual crank linkage is just as positive, but turns wheels at a varying rate as crank leaves vertical. Steering with either system is extremely quick —about ¼ turn, lock to lock. (Honest Charley Speed Shop Inc, Chattanooga)



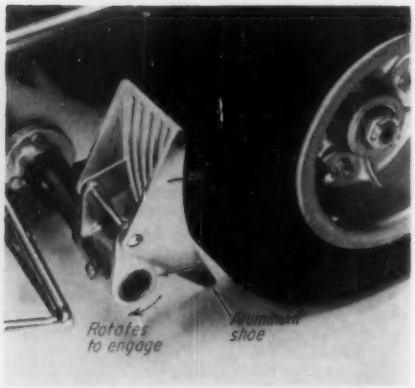
QUICK-CHANGE REDUCTION GEAR steps down 15,000-rpm output from a high-speed engine in two stages. Best gear ratio for highest lap speed differs from track to track. Sprockets can be changed fast to allow experimentation to find this best ratio. Operator selects one of seven drive sprockets to set approximate range, and one of five axle sprockets for fine adjustment for ratios from 8:1 to 11:1. Both shafts turn in needle bearings; multiple chain runs in oil inside housing. (Jim Rathmann Enterprises Inc, Miami)

Engineered Karts continued

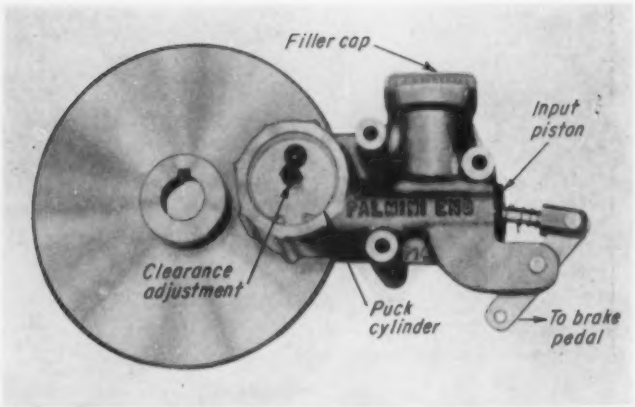
BRAKES



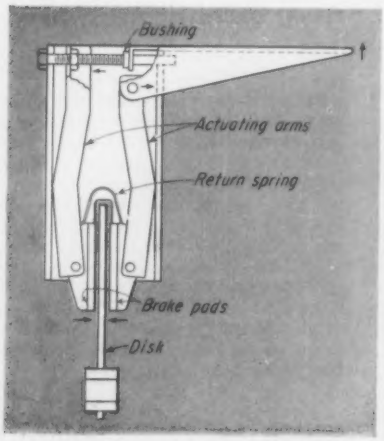
INTERNAL EXPANDING BRAKE has rotating cam that spreads arms which press one leading shoe and one trailing shoe against inside of drum. (Band brakes are sometimes used, but are inferior.) The 6-in.-dia pressed-steel drum bolts on sprocket or, with an adapter, to shaft. Backing plate bolts to flange-bearing for axle. In cars with stub axles, backing plate fits over the nonrotating axle. (Mercury Clutch Div, Automatic Steel Products Inc, Canton, Ohio)

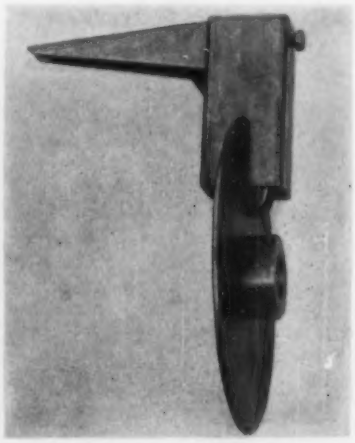


IMPROVED SCRUB BRAKE is self-actuating. Enlarged contact area and heat-dissipating aluminum shoe further increase effectiveness of this simplest of all brake types. Jim Rathmann Enterprises Inc, Miami)

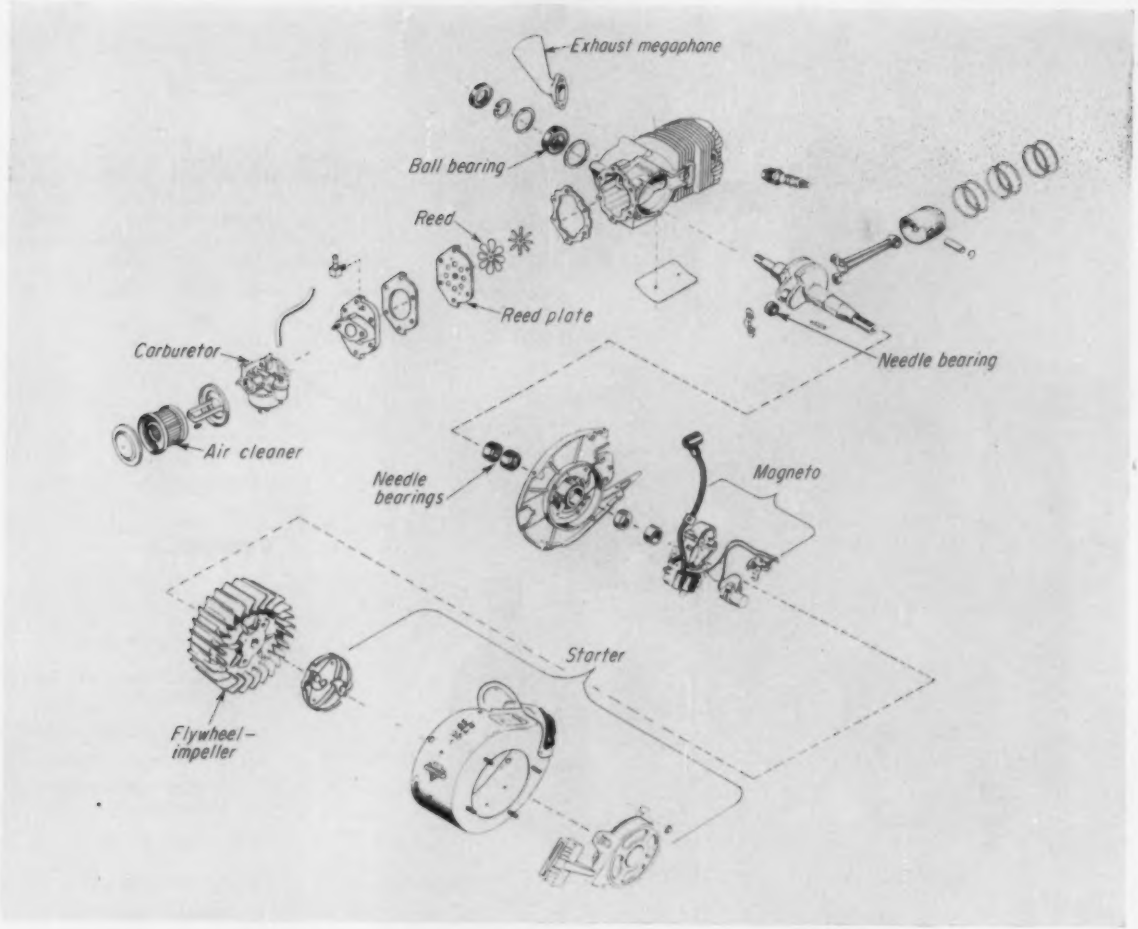


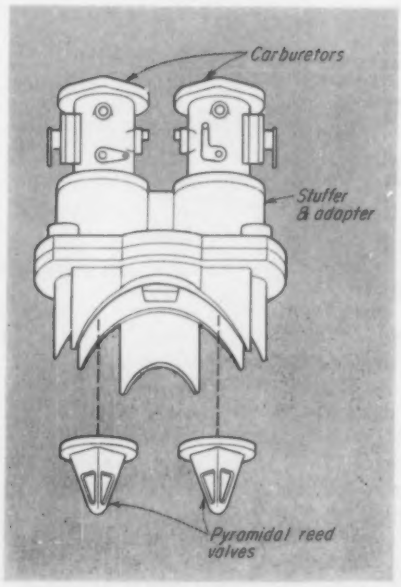
HYDRAULIC SPOT BRAKE has floating disk because only one puck moves. Since linkage is mechanical right up to the brake body, hydraulic section is just force-multiplier. Some other hydraulic spots have a master cylinder, hydraulic lines and wear-compensation. (Palmini Engineering Corp, San Gabriel, Calif)





MECHANICAL SPOT BRAKE is self-centering. Linkage ensures equal and simultaneous braking by both pads, even if one touches disk first, so there is no need for sliding disk or adjustment for worn brake pads. Actuating arms pivot on walls of housing and squeeze disk. Most major parts are made of steel sheet. A simpler but less effective mechanical spot brake presses just one pad against the sprocket. (Go Kart Mfg Co Inc, Azusa, Calif)





TWO-STROKE ENGINES range in displacement from slightly under 5.8 to 8.25 cu in. Larger racing classes use two engines. Typical aircooled engine above delivers 5.2 hp at 6500 rpm. Plain bearings are almost extinct today. Ball, roller and needle bearings are the rule.

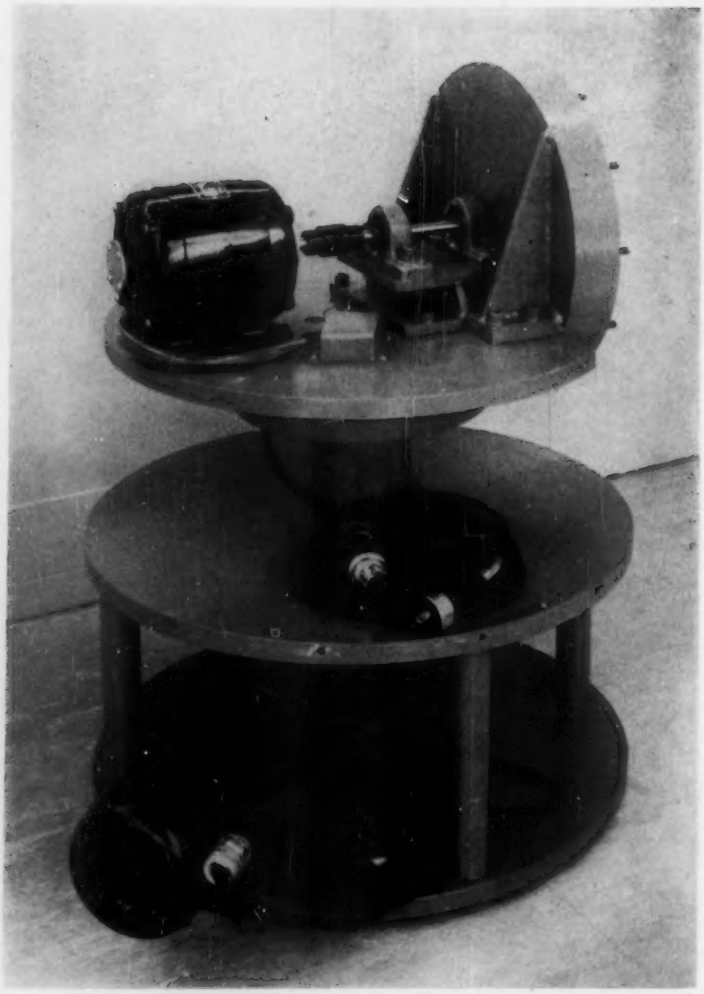
Float carburetor shown here tends to cut out in turns. Diaphragm fuel chambers and pumpers in place of gravity feed eliminate this. Flywheel doubles as impeller in aircooling system, but owners often remove its shroud along with the recoil starter.

Rosette reed valve is one of three types. Another common type has rectangular reeds and rectangular holes in the reed plate; a third type—pyramidal reed—is shown below. (Clinton Engines Corp, Maquoketa, Iowa)

"HOPPED-UP" DESIGNS are almost universal. Parts and work needed to add power are relatively cheap; tools needn't be elaborate. Three-part assembly at left combines dual carburetion, crankcase stuffer and pyramidal-reed valves.

Stuffer increases compression in the crankcase from which the downstroke of the piston pumps a new air-vapor charge to the cylinder. By shrouding the rotating crank, the stuffer also converts the crankshaft into a mild lobe-blower.

Flow through pyramidal-reed valves is more straight-through than with flat-reed plates. (Stuffer by Dunn Engineering Co, Tampa; Reeds by Homelite, Div of Textron Inc, Port Chester, N Y)



NEW METHOD rotates specimen shaft with a ⅛-hp 1800-rpm synchronous motor. Table itself is turned by ¼-hp variable-drive motor (speeds to 92 rpm) giving gyroscopic moment of flywheel that bends shaft.

GYROSCOPIC MACHINE YIELDS BETTER FATIGUE DATA

New version of rotating-beam tester uses gyroscopic moments to induce bending stress in specimen; eliminates stresses arising from bearing misalignment.

DR ROGER S HANSON, *General Motors Research Laboratories, Warren, Mich*

SYMBOLS

M_g—Gyroscopic moment

M_a—Accelerating moment

ω—Angular velocity of horizontal shaft

Ω—Angular velocity of vertical shaft

α—Angular acceleration of horizontal shaft

X—Horizontal axis

Y—Vertical axis

Z—Moment axis

I—Mass moment of inertia of gyroscope rotor

A—Angular momentum

Δ—Increment or change

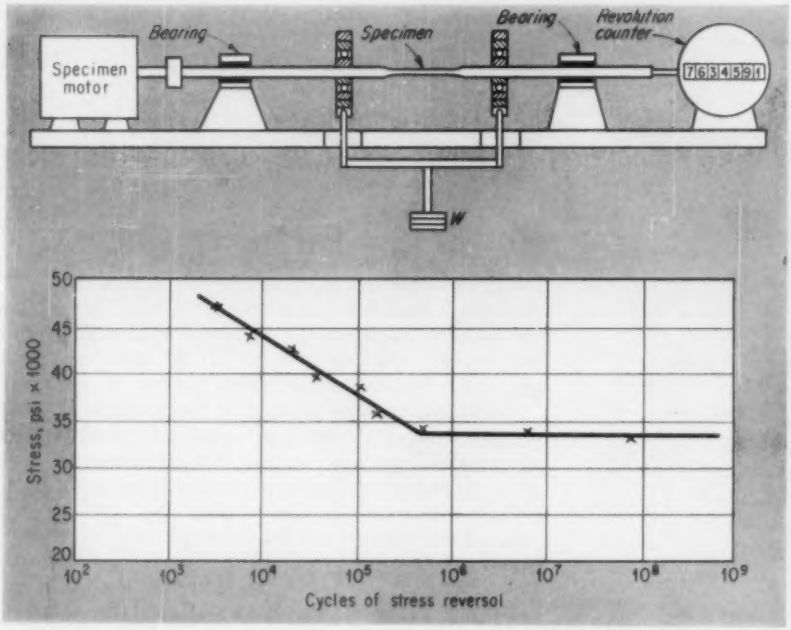
θ—Angular displacement of axis of rotation

W—Weight of solid, circular rotor

S—Fiber stress

r—Radius of shaft specimen

t—Time



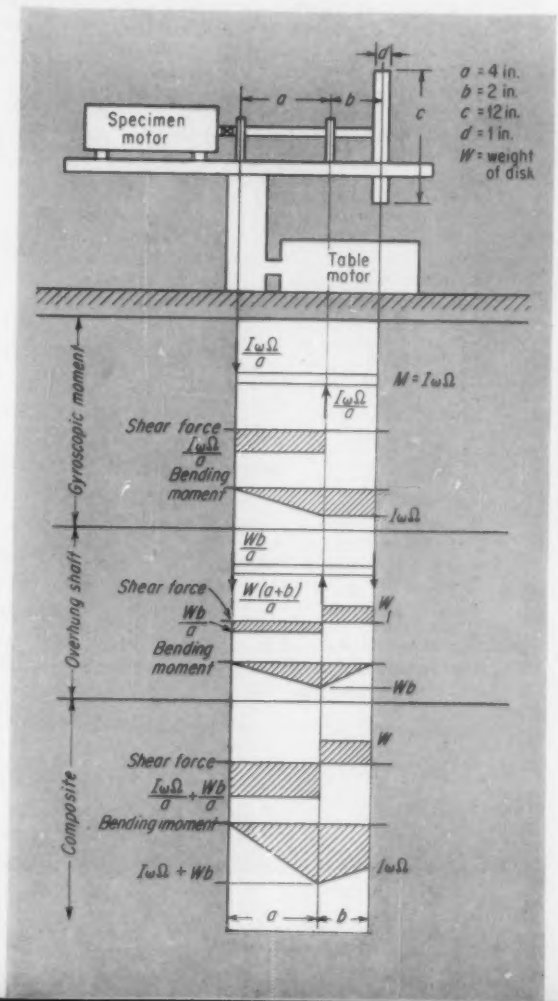
CONVENTIONAL FATIGUE MACHINE (above) tests specimen by reversed-bending method. But a misalignment in bearings induces unknown bending moments. At left is typical S-N diagram for a steel specimen. It shows the stress that can be sustained without failure. Schematic below shows gyroscopic testing machine in typical setup. Series of graphs illustrate effect of the gyroscopic and weight moments.

Endurance limit as determined by fatigue tests is an empirical relationship that depends in part on the design of the fatigue-testing machine. For example, a familiar method subjects the specimen to alternating tension and compression. The other common method, which induces bending in rapidly reversing directions, is employed in the popular rotating-beam fatigue-tester usually found in materials-testing laboratories. A major drawback of this machine has now been overcome.

In the older version of this reversed-bending method, the specimen serves as a rotating shaft in the machine. When rotated by the motor, it is subjected to bending couples by a deadweight load. Stress in each element in the test section changes from compression to tension and back to compression during one revolution. A counter registers the number of revolutions until failure occurs, and the machine stops automatically. Typically, the results of such a test are plotted as an S-N curve with number of cycles on a logarithmic scale.

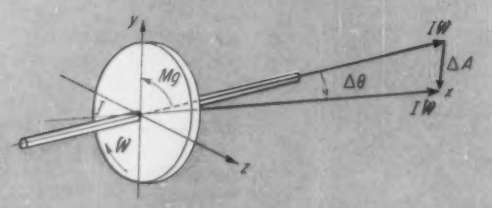
But there is this problem with this conventional setup: Bearing misalignment imposes unknown bending moments on the specimen. If the misalignment is symmetrical between the two bearings its extent can be calculated by means of double integration. But unsymmetrical alignments can occur even in self-aligning bearings, and when they do, it is impractical to measure the extent of the misalignment.

This problem of indeterminate bending moments can be avoided by using the gyroscopic principle to set up the required bending moments. A machine



GYROSCOPE MACHINE YIELDS BETTER FATIGUE DATA continued

The Gyroscopic Principle



A gyroscope is a rigid body that rotates at a relatively high angular velocity about a given axis, called the axis of rotation; it simultaneously rotates or tends to rotate about a second, mutually perpendicular axis at a relatively low angular velocity when subjected to a moment acting about the third mutually perpendicular axis. Usually, the axis of low angular velocity is called the axis of precession, the third axis is the moment axis. These two axes can be, and often are interchanged in practice. For this discussion, the rigid body is a solid circular disk rotating about its axis. The angular momentum of this disk $I\omega$ is a vectoral quality possessing both magnitude and direction. A change in direction is denoted by $\Delta\theta$ and a change in angular momentum by ΔA.

$$\Delta A = I\omega(\Delta\theta) = M_g(\Delta t)$$

or $$M_g = I\omega\frac{\Delta\theta}{\Delta t} = I\omega\Omega$$

where $$\Omega = \frac{d\theta}{dt} = \lim_{\Delta t \to 0}\frac{\Delta\theta}{\Delta t}$$

In this analysis it is important to note that ΔA can mean a change either in direction, magnitude or both. The gyroscopic moment arises from the change in its direction and it lies in a plane perpendicular to the change of direction vector. Significant gyroscopic moments are built up by the fact that the magnitude of M_g varies as the combined product of the mass moment of inertia and the two angular velocities.

using this principle was developed at the General Motors Research Laboratories; it is shown in the photo (p 42); and schematically, lower sketch on p 43. In this machine the specimen is a long, horizontal shaft of uniform section supported on two bearings. One end is rotated by a motor; the other end supports a flywheel that is cantilever-mounted behind the second bearing. Another motor turns the table on which the test equipment is mounted. With the flywheel spinning, rotation of the table sets up a gyroscopic moment on cantilever portion of specimen.

Gyroscopic bending moment in the specimen depends on mass moment of inertia and speed of the flywheel, and the rotational speed of the table. For given mass moment of inertia and speed of flywheel the gyroscopic stress varies directly with speed of table rotation. The total bending moment is a composite of the gyroscopic bending moment and the moment due to weight of the flywheel, (see diagrams, page 43). Similarly, the total fiber stress S is the composite of the gyroscopic stress S_1 and the stress S_2 due to the flywheel weight.

Stress imposed on the specimen can be calculated by these steps.

1. Calculate mass of the flywheel from volume and specific volume where:

$$\text{Volume} = \frac{\pi c^2 d}{4}; \quad \text{weight} = \text{specific weight} \times \text{volume}$$

$$\text{Then, mass} = W/386$$

2. Calculate moment of inertia of flywheel:

$$I = \frac{Wr^2}{2 \times 386}, \text{ lb-in.-sec}^2$$

3. Convert rpm of specimen and table into angular velocity, expressed in radians/sec:

$$\text{Specimen: } \omega = \frac{\text{rpm } 2\pi}{60} \qquad \text{Table: } \Omega = \frac{\text{rpm } 2\pi}{60}$$

4. Calculate gyroscopic moment:

$$M_g = I\omega\Omega \text{ lb-in.}$$

5. Calculate gyroscopic fiber stress:

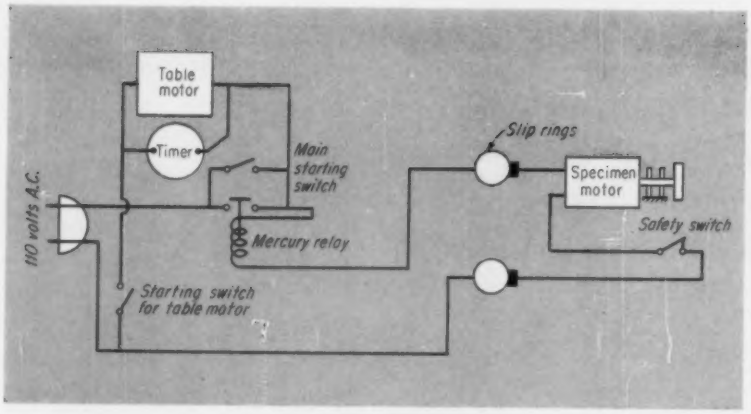
$$S_1 = \frac{M_g r}{\frac{\pi}{4}(r)^4} \text{ psi}$$

6. Add moment due to overhung weight of flywheel and calculate combined fiber stress:

$$\text{Combined } S = S_1 + S_2$$

Recommended procedure for using this machine is to start the horizontal shaft first, allowing it to attain synchronous speed, and then start the table rotation. This permits the disk flywheel to reach synchronous speed before imposing the relatively high gyroscopic moment.

When the specimen breaks, the flywheel housing, which is lined with rubber, quickly brings the disk to a stop.



WIRING DIAGRAM for gyroscopic fatigue-testing setup.

The entire machine is stopped by the disk dropping on a snap-action switch at the base of the flywheel housing. An electric timer in the circuit of the vertical-shaft motor times the test, from which the number of cycles may be computed. The circuit diagram for the machine shows that it is no more complex than a conventional unit, where unknown bending moments due to bearing misalignments make the fatigue data less reliable.

EDITOR'S NOTE: For more information on endurance and fatigue of metals see:

For a Stronger Metal Surface, Nov 14 '60, p 70. Here's a practical guide that compares different methods of boosting wear resistance, bearing and fatigue strength.

Allowable Stresses in Flash-welded Joints, Oct 31 '60, p 39. Shows how flash welding can produce joints as strong as the parent metal, and how to correlate data with magnetic inspection to keep the flaws due to mass production at a low percentage.

Aluminized and Chromized Coatings Change Steel Properties, June 27 '60, p 31. Fatigue properties of steel are improved by method described. New data from Great Britain show how enlarged grain and decarburized zone in chromized steel develop protective properties.

Reserve Strength in Metal Parts, Dec 21 '59, p 45. Shows how to exceed the yield strength of a material and get away with it by designing in the plastic range.

New Coefficients Predict Wear of Metal Parts, June 23 '58, p 71. Analysis of 4 different types of wear; simple formulas employing wear coefficients give answers that can lengthen life of a sliding system.

Critical Frequency of Stepped Shafts, Jan 11 '60, p 57. Gives simplified formulas for calculating critical frequencies with reasonable accuracy—and no need to use differential equations.

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No leakage at high pressures—that's a challenge to integral joints between two different metals. The author gives three ways to meet these requirements, and focuses on the design information you need for . . .

WELDING OR BRAZING DISSIMILAR METALS

JAY BLAND
Manager, Welding Development
Knolls Atomic Power Laboratory, Schenectady*

When design calls for joining dissimilar metals to form a pressuretight seal, welding or brazing is usually better than a mechanical joint. The most common processes for such metallurgical joining are: fusion-welding, brazing and braze-welding. These heat the base metals and join them by melting or by wetting with a third material called the filler metal.

Welding, which gives higher strength and is better suited to field operations, is preferable to brazing, unless the base metals are unsuitable.

The three methods

Fusion welding techniques include arc welding and gas welding. Both methods melt the base metal, which then dilutes the weld deposit and may change its properties.

The amount of base metal melted into the weld for gas welding is less than for arc welding. Manual arc welding typically penetrates ⅛ to ¼ in. into the base metal, giving 15 to 20% dilution in weld beads adjacent to the base metal. Submerged-arc welds penetrate deeper and give as much as 60% dilution of the base metal. When a filler metal is used, it is usually similar to one of the metals being joined, to minimize property gradients.

Brazing permits a wider choice of base metals than welding or braze welding. Because it bonds by wetting, there is no melting, and little of the base metal dissolves into the filler metal. Brazing requires only small quantities of filler metal, which often has better corrosion resistance than the materials it joins. However, this can be a disadvantage when the filler is more noble and shifts corrosion to the other metals in the joint.

Braze welding can fill wide gaps between two metals with a third, which is a lower melting filler. As with brazing, the bond is achieved by wetting. The choice of filler metals is limited, which restricts the field of application.

Weld combinations

In general, any metal that can be welded to itself can be welded to a dissimilar metal. Many metal combinations, however, are not considered practical because they form brittle intermetallic compounds, have low strength or lack soundness. These combinations can sometimes be joined by special welding processes such as pressure welding or forge welding; these avoid brittleness because they limit dilution of base metal.

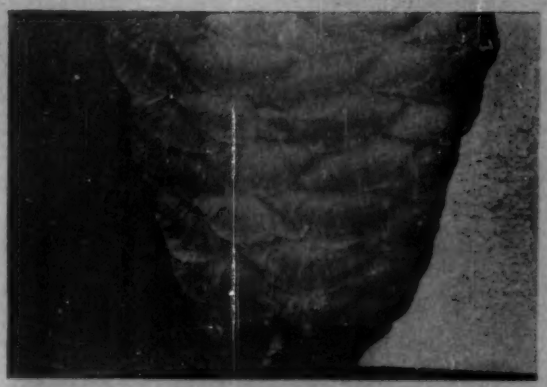
Practically all of the commercial steels, the stainless steels, and the nickel-base alloys can be joined in any combination, and give sound fusion welds. Copper-base alloys can be joined to each other as well as to some nickel- and iron-base alloys. Aluminum and the magnesium-base alloys generally are joined only to similar alloy types. Titanium alloys, and the exotic alloys of zirconium, hafnium, beryllium and columbium, usually are welded only to themselves.

Weld-joint properties

Mechanical or thermal fatigue is the most important source of failure in a dissimilar-metal weld. The best way to check structural integrity is with fatigue-cycling tests. If two metals with different thermal expansion are joined, raising the temperature will cause a differential shear stress often high enough to damage the weldment. For example, a weldment of stainless and carbon steel when heated from room temperature to 1000 F will build up a thermal stress of about 75,000 psi. This exceeds the

* Operated by GE for the AEC.

Photomacrographs show typical weld joints



A

SINGLE U-GROOVE is joint-design used in both of these welds. (A) shows joint between Inconel (left) and 304 stainless. Root radius is 5/16 in.; included angle, 30°. Shielded metal arc was used with modified-Inconel electrode. (B) Inconel-clad carbon steel (left) joined to Inconel.

B

Root radius, 3/16 in.; included angle, 50°. This MIG (metal inert-gas) weld used modified-Inconel wire. In both cases, root pass was TIG (tungsten-arc inert-gas) weld using a consumable Inconel insert to prevent excessive burn-through during welding.

yield strengths of both materials, so that some plastic deformation must take place.

If fatigue is produced by mechanical stress, both base metals should be loaded below their endurance limits. However, if loading deforms one of the base metals plastically and the other elastically, excessive distortion will result.

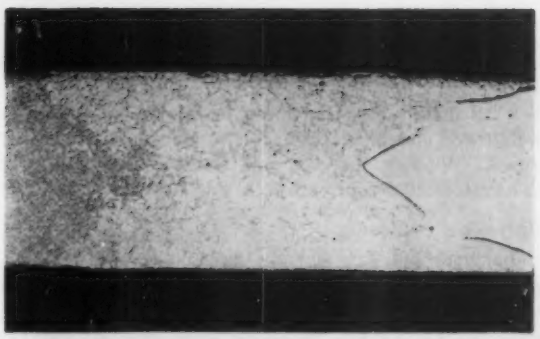
Tensile strength of the weld deposit is usually comparable to or better than that of the weaker of the two base metals. In joints of carbon steel to stainless, or stainless to Inconel, tensile specimens will always break in the weaker base metal.

Low-temperature impact properties of the weldment will generally be limited by one of the base metals. Low-alloy steels and plain carbon steels in particular have poor impact properties at low temperatures. Filler metals usually cause no problems since most fillers for steel, stainless and nickel-base dissimilar-metal welds are solid-solution alloys with high impact properties at low temperatures.

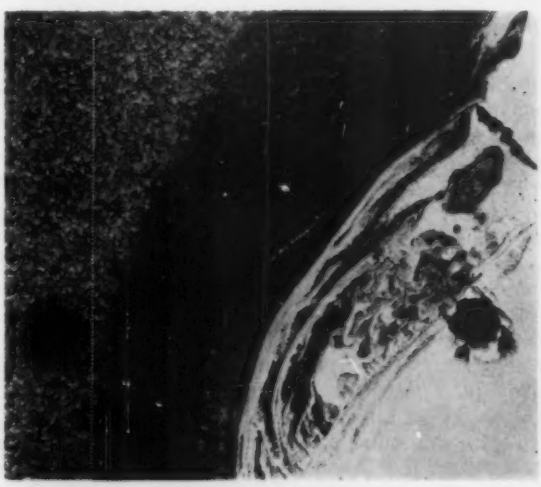
Elevated-temperature creep in the weld will not be much more than in the poorer of the two metals. Usually the weld metal is equal to or better in creep properties than the poorer material.

Post-forming properties are limited by the amount that

continued, next page

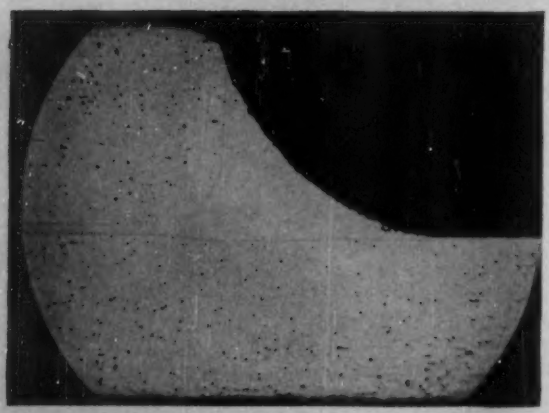


SQUARE BUTT JOINT, with Zircaloy-2 (left) and hafnium (right), was TIG-welded with zero root opening. Weld bead was machined flush with surface of ¼-in. plate.

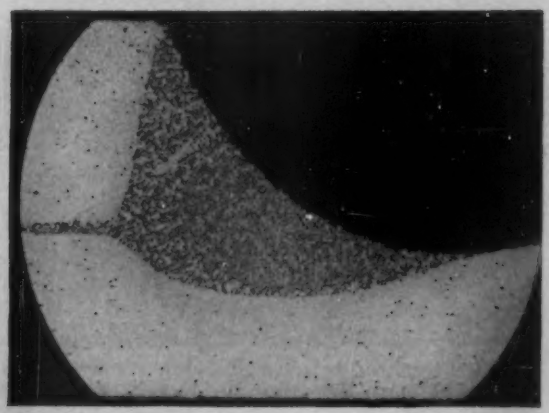


TRANSITION ZONE between 410 stainless (left) and modified-Inconel weld metal is evident in this etched sample. Large dark band (center) is heat-affected zone in 410 base metal; the two round dark spots are hardness-test indentations.

Penetration depends on braze-metal filler



SHALLOW penetration results, as shown above, when Inconel is brazed with gold-nickel filler metal.



DEEPER penetration is noticed when nickel-chromium-silicon-boron is the filler metal.

the less ductile base metal can be worked. Usually the weld metal chosen is as formable as the more ductile base metal. Welding, however, will usually lower ductility in the heat-affected zones on both sides of the weld.

Corrosion resistance

Coupling the two materials by a weld may establish galvanic corrosion. If both base metals adequately resist the corrosion environment, the filler metal used to join them will be adequate because it is usually similar to the better of the two base metals. Corrosion may be accelerated between the weld metal and the poorer of the two base metals because thermal expansion causes stresses that coincide at the same location.

Distortion

In general, distortion is minimized by low weld-heat input per unit length of joint. Good welding sequences on symmetrical designs—such as welding on alternate sides of a double-V groove—will give less distortion than welding from one side on a single-V groove.

In a dissimilar-metal weld, the weld deposit may shrink unevenly at one side of the weld, causing more distortion than in a normal weld. If the filler metal is different from the two base metals, distortion will be even more difficult to predict without a test weldment.

Stress-relief heat-treatment to reduce distortion may impose new problems—the temperature satisfactory for one material may produce undesirable metallurgical changes in the other material. For example, the usual post-heat temperature for carbon- or low-alloy-steel materials (about 1150 F) will cause carbide precipitation in austenitic stainless steel if it is not stabilized.

Stress distribution

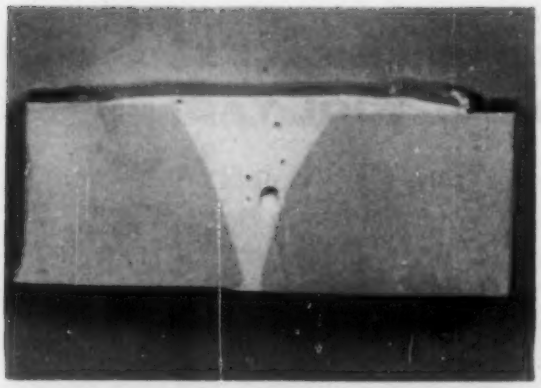
Usually, residual stresses in welds are in tension on the surface, balanced by compressive stresses within the body of the material. This stress pattern is distorted when a ductile, low-strength material is welded to one with a high yield strength.

Residual stresses after post heat-treatment can be estimated since the treatment lowers residual stresses to the yield point of the material at the heat-treating temperature. For example, carbon steel welded to austenitic stainless with an austenitic filler metal and stress-relieved at temperatures for carbon steel, will result in residual stresses of about 6000 psi in the carbon steel, and as high as 20,000 psi in the austenitic base metal and the austenitic weld deposit. This residual-stress difference can cause uneven distortion when service loads are superimposed on the residual stresses. This distortion may easily be more than expected on the basis of the original design calculations.

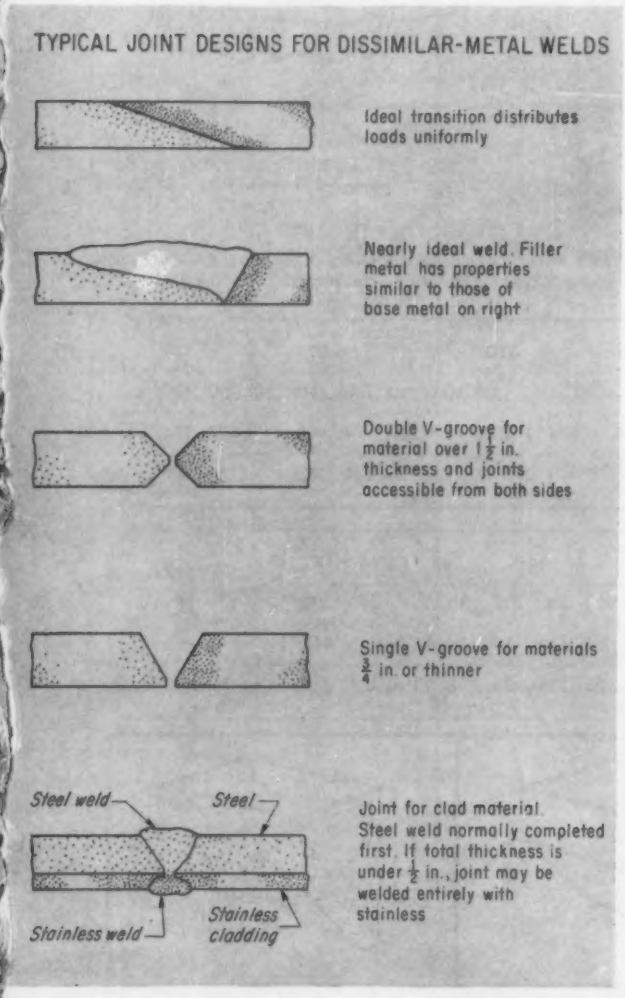
Simplify the design

When other requirements allow free choice of base metals, they should match in thermal expansion if the joint is exposed to thermal cycling. If service temperature is steady but the atmosphere is corrosive, then thermal expansion is less important than resistance of both base metals to the particular environment. Matching yield strength and modulus will give more uniform load distribution across the dissimilar-metal weld.

When the base-metal combinations are limited, some benefits may be gained in selection of the filler metal. A filler with an expansion coefficient between those of the base metals will minimize the thermal stress. This



BRAZE-WELD with copper-base filler metal joins steel plate. This process, commonly used to join cast iron, does not penetrate deeply into base metal. The porosity shown is common in these braze-weld deposits, but can be eliminated by changing technique or joint-design.


TYPICAL JOINT DESIGNS FOR DISSIMILAR-METAL WELDS
Ideal transition distributes loads uniformly
Nearly ideal weld. Filler metal has properties similar to those of base metal on right
Double V-groove for material over 1½ in. thickness and joints accessible from both sides
Single V-groove for materials ¾ in. or thinner
Steel weld
Steel
Stainless weld
Stainless cladding
Joint for clad material. Steel weld normally completed first. If total thickness is under ½ in., joint may be welded entirely with stainless

kind of gradual transition is desirable also for mechanical properties. But both materials must be resistant to corrosion.

Changes in section should be placed in one of the base metals, rather than at the transition joint. The notch effect of the section will concentrate stresses in the dissimilar-metal weld.

Shop welds are best when dissimilar-metal joints are used in high-pressure or other critical service because shop welding gets much better supervision and can be performed under better control. Where parts must be joined to dissimilar-metal piping, the transition is usually shop-made. This type of design is preferable although this may mean two field welds between similar metals instead of one dissimilar-metal weld. All dissimilar welds for atomic energy work are shop-welded where possible.

Some service experiences

A filler metal should not be chosen merely for easy-welding characteristics. Stainless 18-8 weld metal often used to weld 5 Cr-0.5 Mo ferritic steel can cause joint failures for two reasons: Carbon depletion from the ferritic base metal into the low-carbon stainless weld lowers shear properties of the heat-affected zone; and different thermal expansion of the two materials results in high shear stresses along the same zone that has reduced mechanical properties from carbon migration.

Carbon diffusion will also occur in joints between two ferritic steels with different chromium content. Carbon will migrate from the lower-chromium to the higher-chromium alloy.

A stainless-lined vessel that is alternately heated and cooled should be made from clad material rather than welded-on plates. In clad material, the bond between the stainless and plain-steel backing carries some of the loads from differential expansion.

When stainless liners are welded to ordinary steel, alternate compressive and tensile loads from heating and cooling concentrate at the weld seam. Even though an austenitic weld is ductile, it will eventually crack. The exposed carbon steel will then corrode rapidly because it forms a cell with the lining that is supposed to protect it.

Code requirements

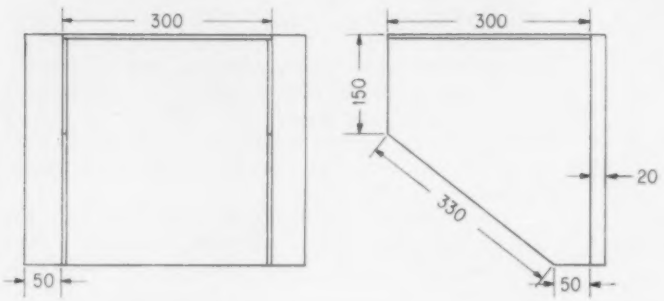
Construction codes, such as the ASME code for Unfired Pressure Vessels, permit dissimilar-metal welds in fabrication, but require separate qualification tests of the welding procedure. These tests, which check tensile strength and weld soundness, must be made even if the procedure for each base metal has previously been qualified. When the metals are similar, service life can be estimated from properties of the base metals and filler metal, and from tensile data obtained by qualification test. Welds between widely different materials or those for critical service will require additional tests such as thermal and mechanical fatigue.

EDITOR'S NOTE: These and other methods of joining dissimilar materials are given in: **Designing Brazed Joints for 1000 F and Above,** Aug 1 '60, p 40; **Electron Beam Welds in Vacuum,** July 18, '60, p 70; **Before Tackling the Refractory Metals,** May 25 '59, p 43; **One Temperature for Successive Brazes,** Dec 8 '58, p 84; **Glass-to-Metal Seals,** Jan '57, p 188.

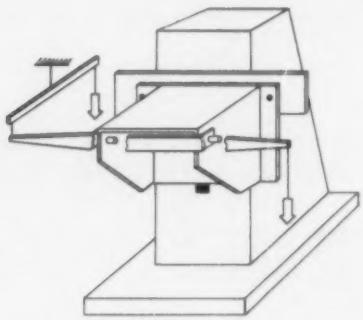
HOW CUTOUTS and BRACES AFFECT MACHINE-TOOL TABLES

These comparative stiffness values for 30 designs are digested from an article by K Loewenfeld in *Der Maschinenmarkt* (Wurzburg, W. Germany), No. 79, Oct '59.

Add braces to a machine-tool table and you increase stiffness; cut out slots or holes and you decrease it. To find the relative effect of various stiffeners and cutouts, researchers at the University of Munich found the relative torsional stiffness (based on an arbitrary standard shown below) of several representative designs. Tabulation on this page gives the results, including comparative stiffness-to-weight ratio for each design. Figures 1 to 8 show the reinforced designs; 9 to 18 show the cutout versions.



Dimension in millimeters
7.5 mm plate except for back

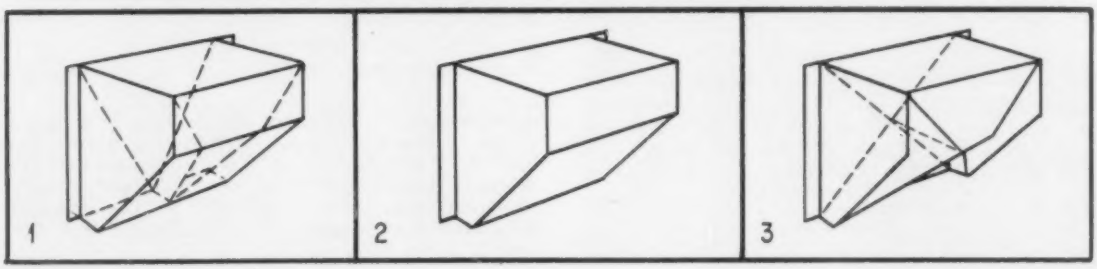


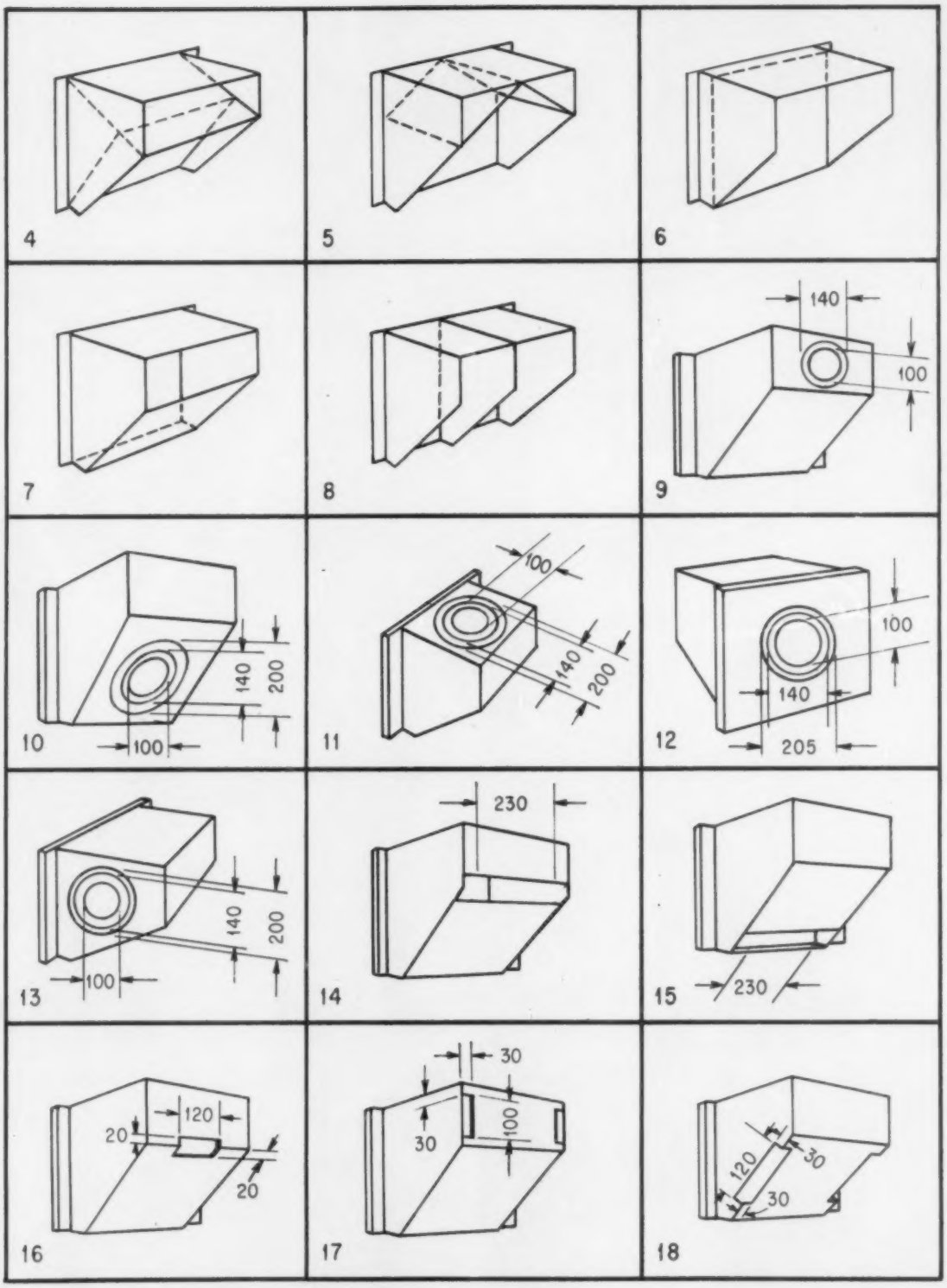
STANDARD DESIGN received arbitrary rating of 1.0 for both torsional stiffness and stiffness-to-weight ratio.

TEST RIG determined the effect of stiffeners and cutouts by comparing each design against the standard.

Table Number	1	2	3	4	5	6	7	8	STD	9		10			11		
Key dimension, mm										100	140	100	140	200	100	140	200
Comparative torsional stiffness	436	223	97	53	44	16	4.1	1.2	1.0	159	109	174	168	112	223	174	121
Comparative torsional stiffness/weight	279	175	69	39	35	14	3.4	1.0	1.0	123	86	136	133	91	176	140	101

Table Number	12			13			14		15		16	17	18
Key dimension, mm	100	140	205	100	140	200	230	300	230	300	120	100	120
Comparative torsional stiffness	182	174	146	175	134	62	145	30	145	18.2	146	144	194
Comparative torsional stiffness/weight	145	142	123	139	109	53	115	24	107	13.4	116	112	142

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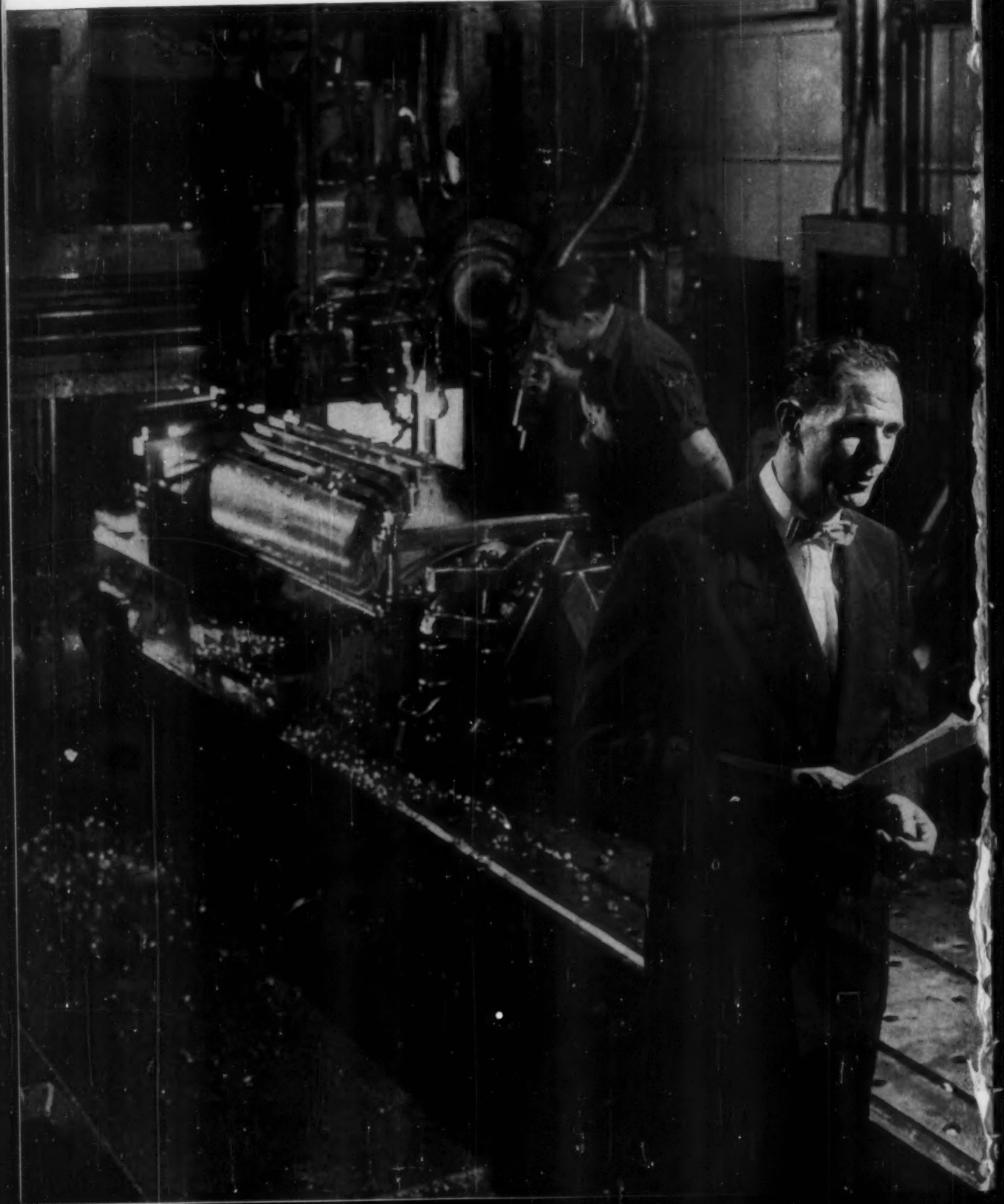
THE MAN & THE DRIVES



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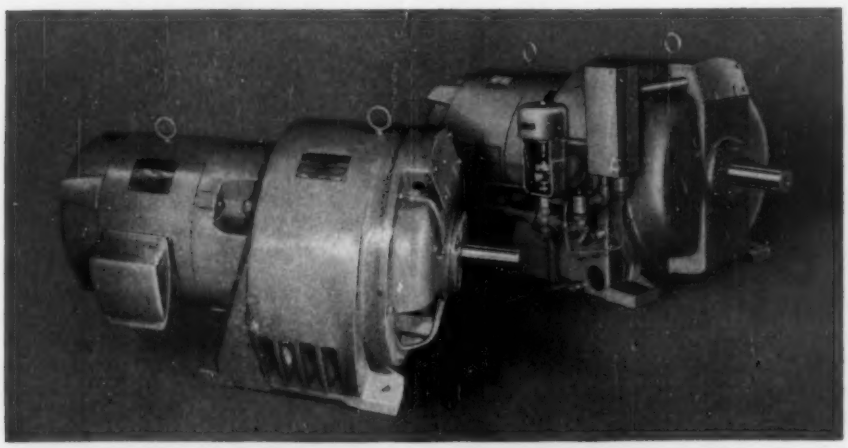

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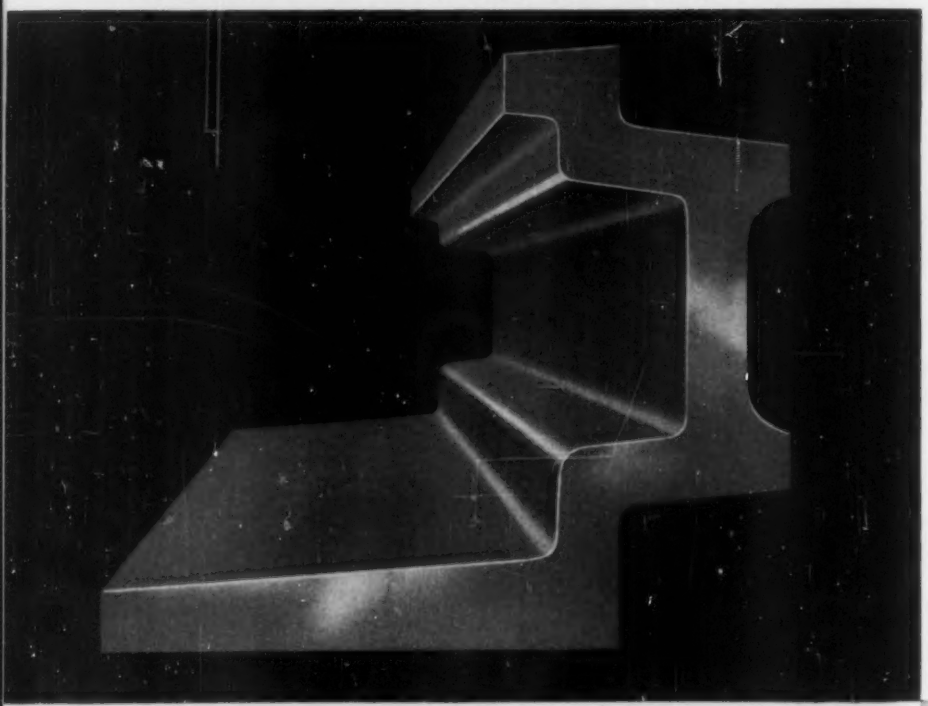

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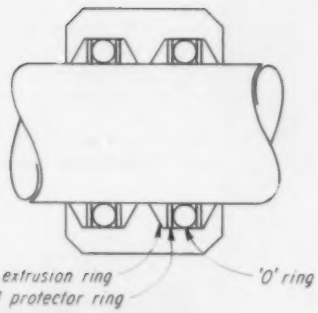
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Seal-ringe assembly . . .

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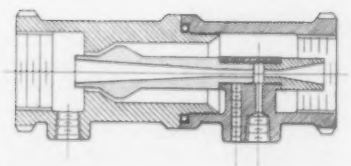

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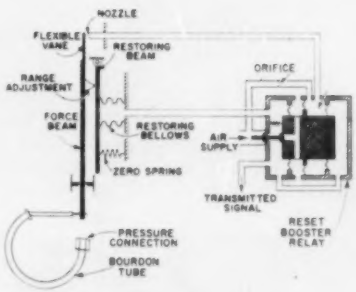
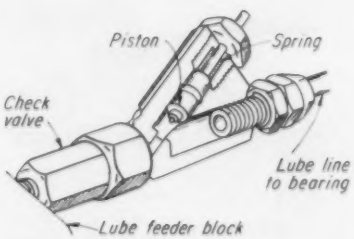


Pressure transmitter . . .

consists of a force-balance mechanism driven by a Bourdon tube and provides up to 1 to 10-span suppression to measure small pressure increments. Expands small pressure increment to cover full signal range for accurate measurement or control. All measurements are transmitted over standard SAMA signal range of 3 to 15 or 3 to 27 psig. Signal is said to be accurate within ½% of metered range span. Comes in five pressure ranges up to 7500 psig. Available about June 1 at $300 through $400. **Bailey Meter Co, 1050 Ivanhoe Rd, Cleveland 10.**

Circle 303 on Reader Service Card



All-hydraulic broken line indicator . . .

gives warning signal at lubricating system's pump or control point. Pin in indicator's body retracts, giving visual indication of trouble spot. When break occurs, pressure drop causes indicator's spring-loaded piston to shut small entry port. Pump must build up pressure to overcome temporary spring-controlled blockage. Kits (available from stock at less than $10), consisting of indicator, check valve and simulator, are suitable for grease and oil and circulating oil systems. Spring pressures range from 400 psi for circulating oil to 1200 psi for large grease systems. **Trabon Engineering Corp, 28815 Aurora Rd, Solon 39, Ohio.**

Circle 304 on Reader Service Card

Mechanical-power amplifier

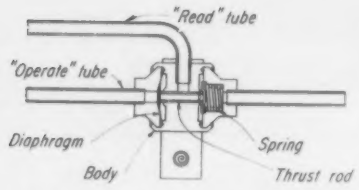
is said to provide up to 2½ times greater torque output than other units. Replaceable windlass-operating part amplifies 1/30-hp output of low-power, 2-phase servomotor to 4 hp. Offers continuous power over a 50:1 speed range. External cooling system recirculates oil in box throughout housing. **Electronics Div, Seneca Falls Machine Co, Fyfe Bldg, Seneca Falls, NY.**

Circle 305 on Reader Service Card

Indicating and loading valve . . .

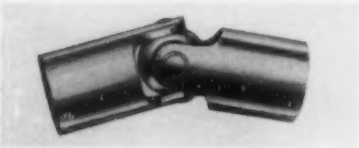
is made of tin-plated alloys and is designed to be buried underground with pressurized cable, such as that used in telephone industry. "Operate" and "read" tubes are led to surface. Pneumatic pressure on "operate" tube opens spring-

continued on page 56



loaded valve, and amount of air pressure in underground cable is indicated on "read" tube. Air can be supplied to cable by applying approximately 20 psig greater pressure through "operate" tube than that being registered on "read" tube. From stock at $17.27 each in quantities of less than 10. George W Dahl Co Inc, 86 Tupelo St, Bristol, R. I.

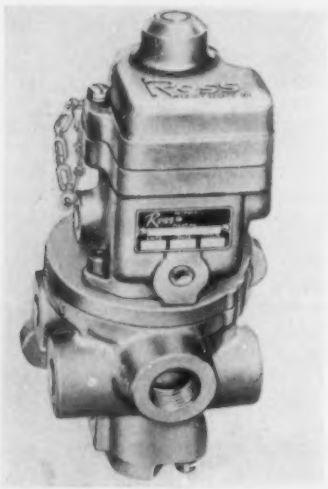
Circle 306 on Reader Service Card



Single, double universal joints . . .

handle speeds up to 1500 rpm. Single joints operate through 40° full working angle; double joints, through 80°. Rated at 0.35 to 190 hp at 100 rpm in sizes from ⅜ to 4 in. Lovejoy Flexible Coupling Co, 4856 W Lake St, Chicago 44.

Circle 307 on Reader Service Card



Inline air valves . . .

made of anodized aluminum alloy, handle 30 to 150-psig air (or other fluid) pressures in head and 5 to 150 psig in body. Operate at 40 to 175 F, with ambient air range from 40 to 120 F. Lightweight moving parts are said to up response time 20 to 30%. Air- or solenoid-operated valves are available in straightway and 3- and 4-way types for ¼ to 1½-in. pipe sizes. Ross Operating Valve Co, 120 E. Golden Gate Ave, Detroit 3.

Circle 308 on Reader Service Card

Epoxy adhesive . . .

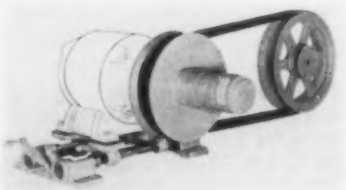
cures in 60 sec at room temperature and in 45 sec with use of infrared lamps. Can bond metal to metal; plastic to metal; plastic to plastic or any other porous or nonporous surfaces. Suitable for automatic meter-mixing-dispensing units in rapid production-line work. Allaco Products, 238 Main St, Cambridge 42, Mass.

Circle 309 on Reader Service Card

Multiswitch cam timer . . .

has external clutch which permits automatic reset regardless of time cycle. Any time cycle from 1 sec to 60 hr can be specified. Available with two to five load switches. Four 115-v, 60-c models are priced from $25.50 to $43.50. Delivery in 6 to 8 wk. Industrial Timer Corp, 1407 McCarter Hghwy, Newark 4, NJ.

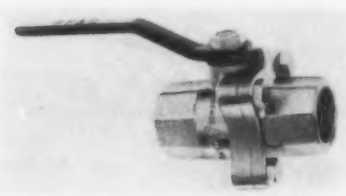
Circle 310 on Reader Service Card



Variable-speed drive . . .

using single belt, delivers 25 hp at 1750 rpm and 3:1 speed ratio. Rack-and-gear arrangement allows equal linear movement to each pulley disk. One disk moves opposite other, causing belt to travel on fixed centerline throughout speed range. Other sizes from ½ hp also are available. Gerbing Mfg Corp, Elgin, Ill.

Circle 311 on Reader Service Card



Ball valve . . .

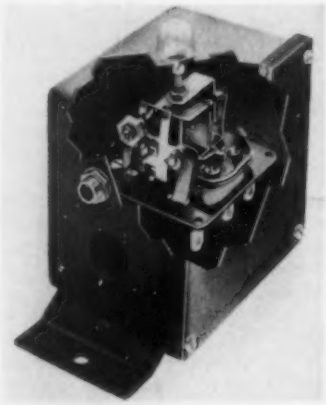
priced competitively with gate or globe valve, requires only ¼ turn of handle to open or close. Wiping action of ball across sealing seats prevents abrasive wear that causes leakage. Suitable for 300 lb of water, oil or gas at a max temperature of 250 F. Available in ¼ to 2-in. sizes. R-P&C Valve Div, American Chain & Cable Co Inc, Reading, Penna.

Circle 312 on Reader Service Card

Pressure transducers . . .

rated from 3-15 to 0-10,000 psig, indicate input in digits. Output is suitable for entry into printers, card and tape punches, and light banks. Readout is possible in steps of 0.01 psi for low pressures; and 0.1 1 and 10 psi for higher pressures. Stainless steel elements are available for corrosive-gas or liquid applications. Datex Corp, 1307 S Myrtle Ave, Monrovia, Calif.

Circle 313 on Reader Service Card



Safety switch . . .

rated at 5 amp, 110 v ac, shuts down equipment when vibration or shock could result in destruction. Said to be sensitive to abnormal oscillation in two planes of motion. Can be wired to ground ignition, sound alarm, activate control panel lights or operate shutoff valves or electric motor-controller circuits. Prices range from $29.50 to $53 for explosionproof model. Frank W Murphy Mfg Inc, 3131 S Sheridan Rd, Tulsa, Okla.

Circle 314 on Reader Service Card

Anti-backlash gears . . .

are offered in predetermined tooth loadings at stock gear prices. Available in AGMA Precision Classes 1 and 2 in 32, 48, 64, 72, 96 and 120 diametral pitches. Cone in both aluminum and stainless steel. Atlas Precision Products Co, Dept A, 3801 Castor Ave, Philadelphia 24.

Circle 315 on Reader Service Card

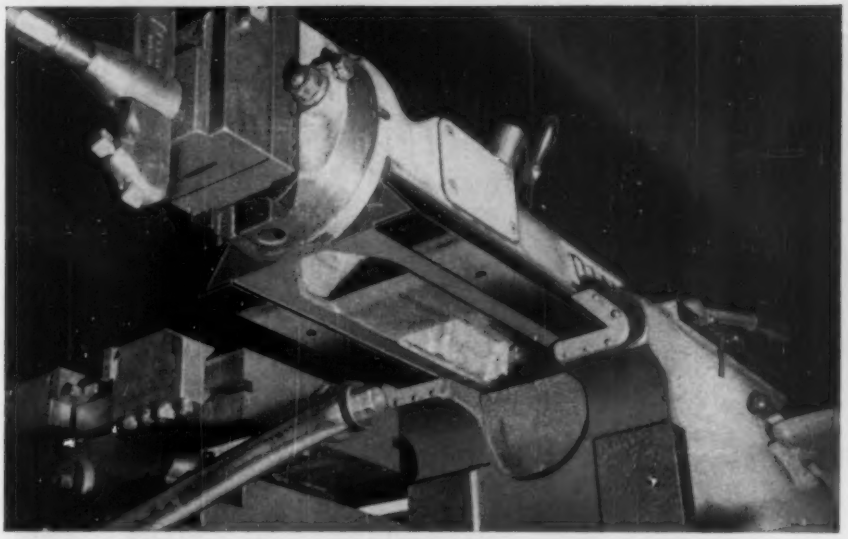
High-pressure filter . . .

made of all-stainless steel, operates at 6000 psi and has leaktight O-ring sealed assembly. Reusable filter element reportedly

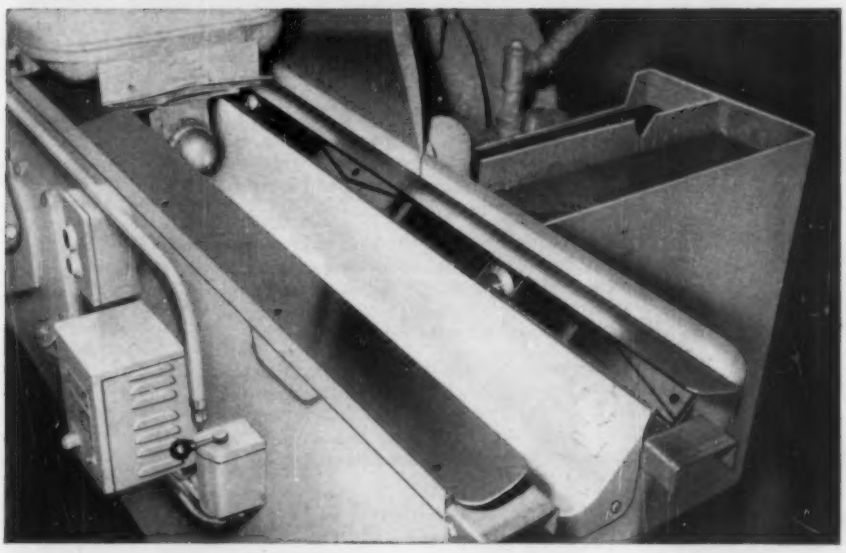
continued on page 58

WEAR PLATES

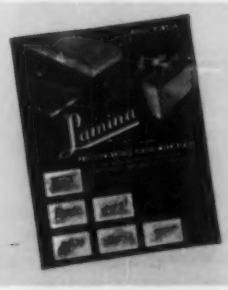
ANOTHER *Lamina* BRONZE-PLATED PRODUCT



Lamina bronze–plated wear plates used on shaper ways.



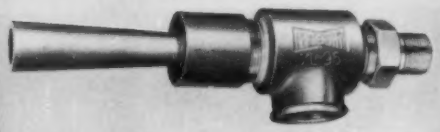
Lamina bronze–plated wear plates used on grinder ways.



Lamina bronze-plated wear plates and their many uses are completely described in Bulletin WP-58. Send for your free copy.

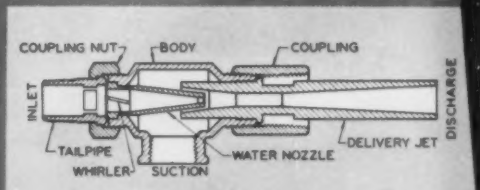
Lamina
DIES AND TOOLS, INC.
P.O. BOX 31, ROYAL OAK, MICHIGAN
Phone: JOrdan 6-8711

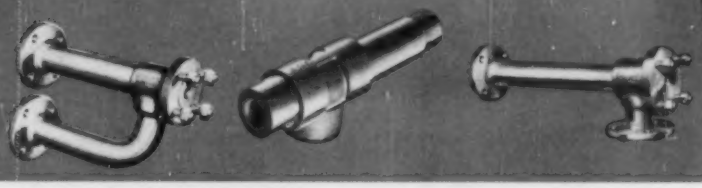
AVAILABILITY



From leading distributors coast-to-coast

JET PUMPS BY PENBERTHY





When you want something . . . like a jet pump, for example . . . you *want* it. Not day after tomorrow, or next week, but *now!* Right? And that's just one more advantage of Jet Pumps by Penberthy. Availability . . . *now*.

Penberthy, to begin with, has a broader line with more models and sizes to offer . . . hydraulic, air or steam operated . . . in bronze, iron, stainless steel, monel, plastic and other materials. Penberthy, in addition, offers "standards" on many designs that would be labeled "special" by other manufacturers.

Add to the above, Penberthy's nationwide network of representatives and stocking distributors. They're located in all the major metropolitan areas so, chances are, there's a Penberthy man near you. Be happy to supply his name and address . . . write or call the Penberthy sales office at the address below . . .

PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
PROPHETSTOWN, ILLINOIS
SALES OFFICE: 2660 E. GRAND BLVD., DETROIT 11, MICH.

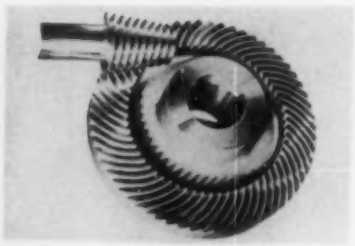
PENBERTHY
Dedicated to Quality Since 1886

GENTLEMEN: Would like more information.
Please send your Jet Pump Catalog #512R.

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____

withstands high differential pressures and stops particles down to 5 microns. All-threaded assemblies are treated to prevent galling. **Fluid Dynamics Inc, 90 West St, New York 6.**

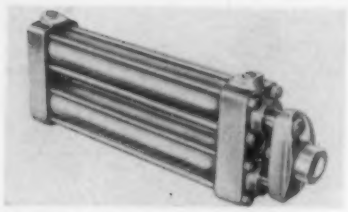
Circle 316 on Reader Service Card



Spiroid gears . . .

in $\frac{1}{8}$-, $\frac{5}{16}$- and $\frac{1}{4}$-in. shaft sizes, have multi-tooth contact design which ups precision control. From stock for right-angle-gearing applications. **PIC Design Corp, 477 Atlantic Ave, East Rockaway, NY.**

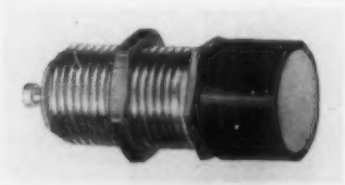
Circle 317 on Reader Service Card



Double-acting hydraulic cylinders . . .

with "center-hole" construction, are designed as "push" cylinders, but have sufficient "pull" force to return ram from such work as punching, forming and broaching where spring return is inadequate. Operate at 10,000-psi pressure. Twin-cylinders are available in 17-, 30- and 50-ton capacities and in the following bore sizes: two $1\frac{1}{2}$ in.; two 2 in.; and two $2\frac{1}{2}$ in. **Precision Hydraulics Div, Owatonna Tool Co, Owatonna, Minn.**

Circle 318 on Reader Service Card



Shrouded panel indicator light . . .

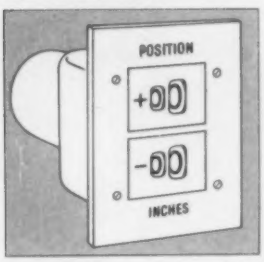
allows no light emission from sides. Mounts in $\frac{3}{8}$-in.- dia hole and available in two-color version—colored when lit, white

continued on page 62

Veeder-Root READOUT Bulletin

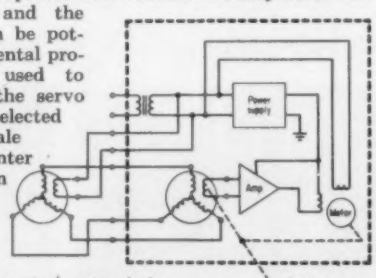
Readout Counter used in Tape Preparation for Machine Tool Control

A Veeder-Root Series 1538 Remote Data Readout Counter provides tape feed control for the motorized tape punching unit of the new Potter & Johnston Tape Control System. The tape punch is used to program machine functions on P & J Automatic Turret Lathes. The counter automatically controls the amount of tape feed required for each turret face involved, and stops the tape at preselected address points. When the correct address point is reached, a combination of holes representing the machine command is punched into the tape. Counter is automatically reset for each turret face.



Servo Repeaters Drive Counters to Indicate Lineal Motion*

One of the ways to take advantage of digital readout for indicating and recording information at remote points is through servo repeaters. Applications in aircraft, for altimeters, navigational displays and similar instrumentation, suggest many other opportunities to use counters for more positive indication and control. A typical "system" is shown here where a counter is used for indicating nuclear reactor rod position. The servo repeater and counter actually form one packaged unit, and the whole device can be potted for environmental protection. When used to drive counters, the servo gear ratio is best selected to provide full scale travel of the counter for one revolution of the control transformer shaft.



Typical servo repeater/counter device that converts synchro data to digital readout.

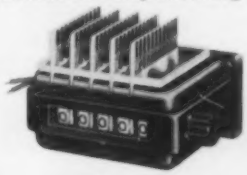
Let Veeder-Root help you make Counters do more! Extensive design experience and precision production techniques make it possible for Veeder-Root to help you solve a wide variety of digital, readout, control and recording problems with counters — from the simplest ratchet to advanced readout and navigational devices. Send for information on specific applications or contact your local Veeder-Root Counting Engineer.

*Reprinted from CONTROL ENGINEERING June 1959. Copyright© 1959 by McGraw-Hill Pub. Co., Inc. All rights reserved.

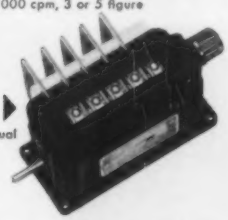
Veeder-Root Readout Device

This is the basic series of Remote Data Readout Counters. Some are available for standard applications, or design variations will be submitted based on requirements. They function basically as analog to digital converters.

Series 1538/electrical reset/ electrically actuated. Speed 1000 cpm, 3 or 5 figure



Series 1538/electrically actuated/ manual reset. Speed 1000 cpm, 3 or 5 figure



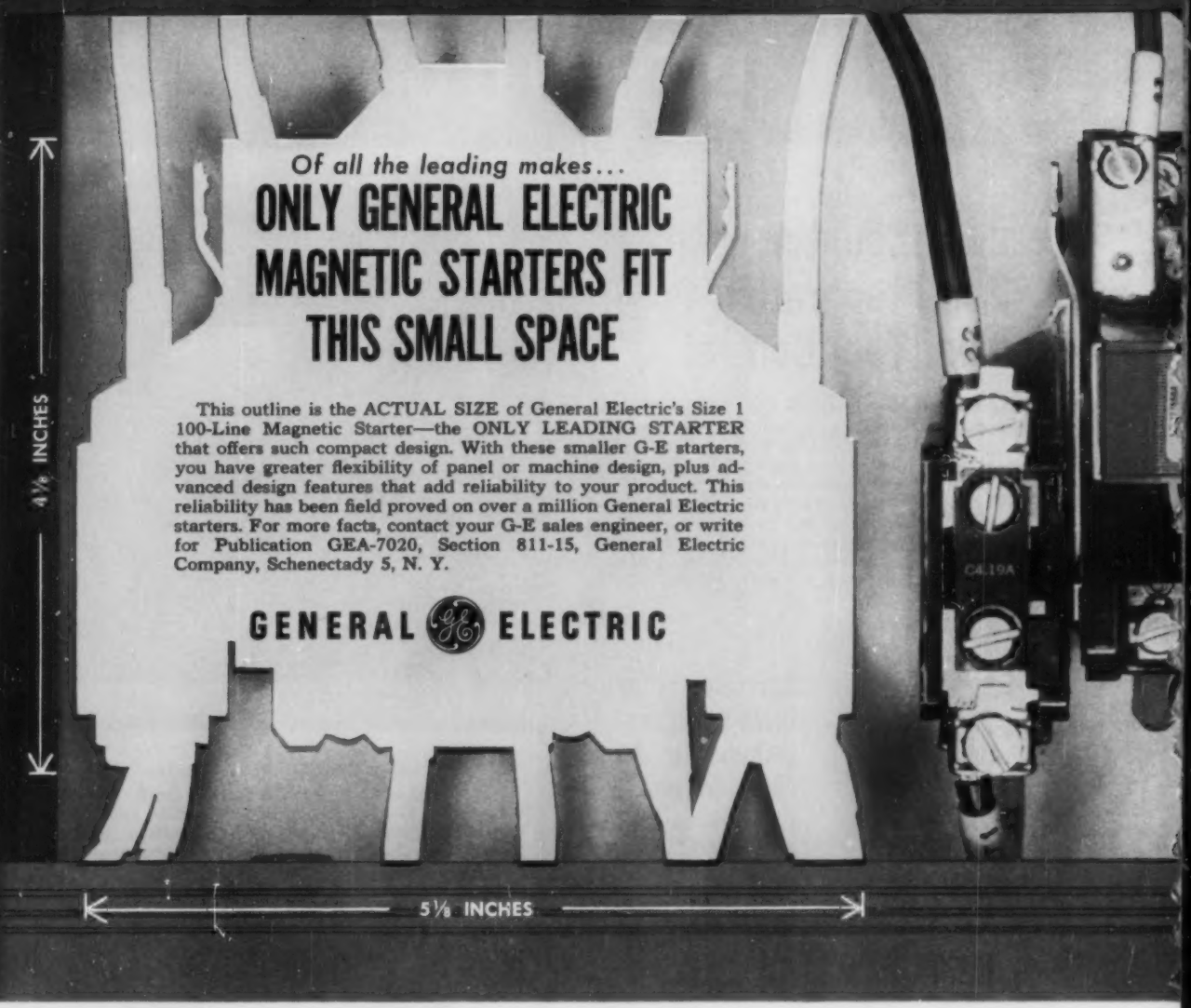
Series 1606/mechanically actuated manual reset standard; bi-directional (non-reset) available. Speed 5000 cpm, up to 5 figures

Veeder-Root

HARTFORD 2, CONNECTICUT

"The Name that Counts"

New York • Chicago • Los Angeles • San Francisco • Seattle
St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal
Offices and Agents in other principal cities



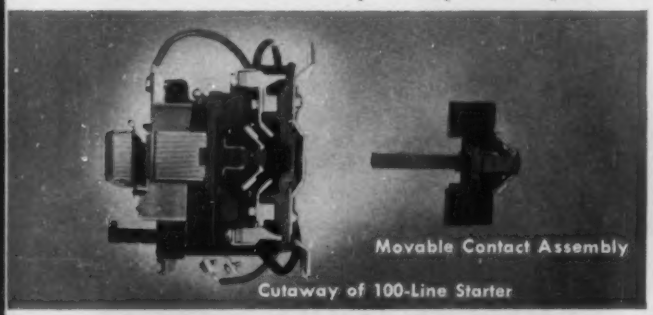
Of all the leading makes...

ONLY GENERAL ELECTRIC MAGNETIC STARTERS FIT THIS SMALL SPACE

This outline is the ACTUAL SIZE of General Electric's Size 1 100-Line Magnetic Starter—the ONLY LEADING STARTER that offers such compact design. With these smaller G-E starters, you have greater flexibility of panel or machine design, plus advanced design features that add reliability to your product. This reliability has been field proved on over a million General Electric starters. For more facts, contact your G-E sales engineer, or write for Publication GEA-7020, Section 811-15, General Electric Company, Schenectady 5, N. Y.

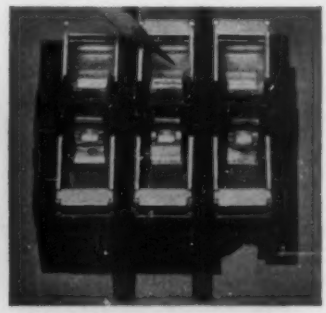
GENERAL ELECTRIC

Add reliability to your product by using 100-Line starters



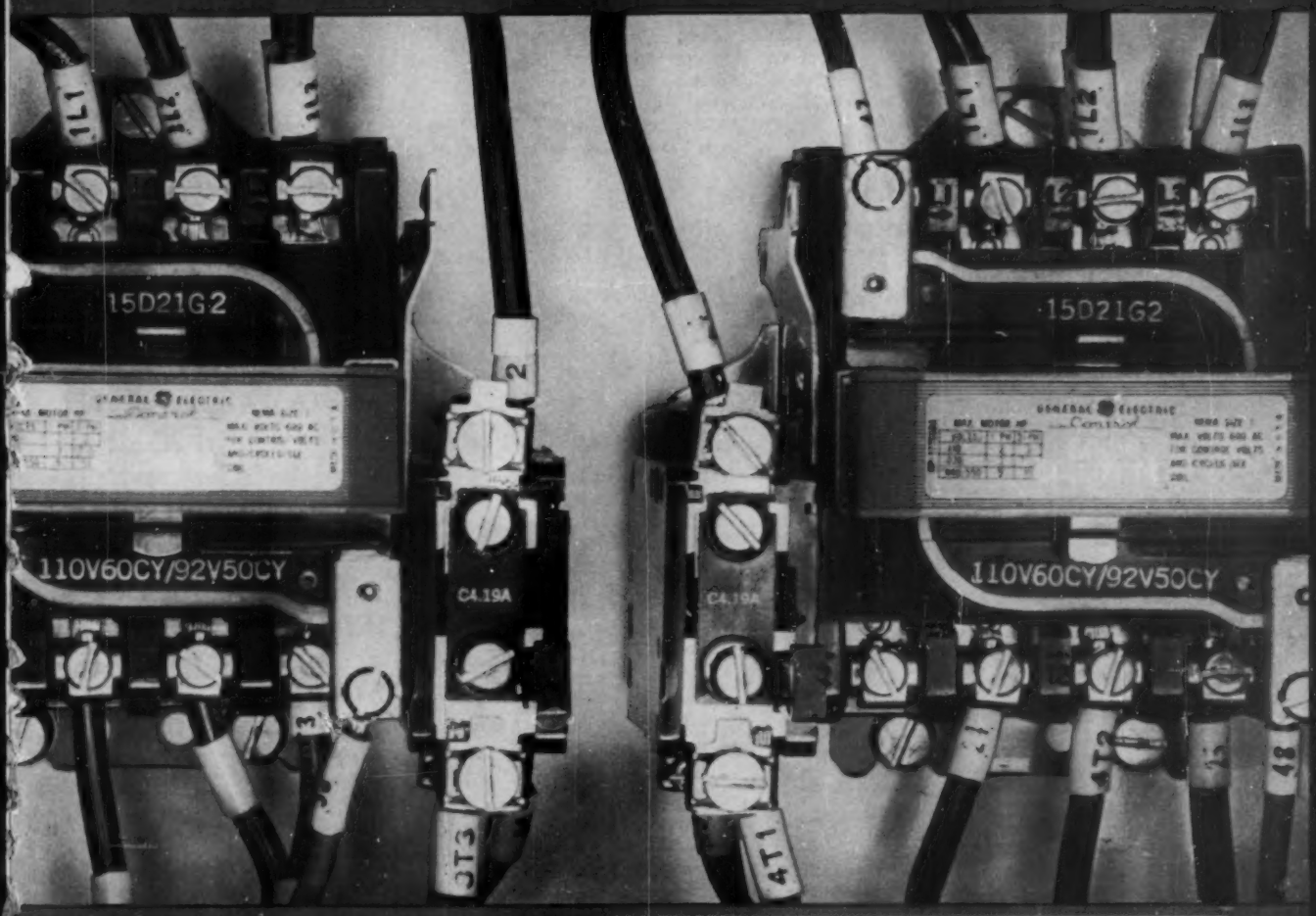
Cutaway of 100-Line Starter

LESS BOUNCE, LONGER LIFE RESULT FROM SLANTED CONTACT DESIGN, HORIZONTAL ACTION. Bounce on closing and dust accumulation are two major causes of contact deterioration. General Electric's slanted contacts and horizontal action virtually eliminate both problems. The unique angled mating of contact surfaces provides positive "make" and "break," with less bounce, less resultant arcing. The slanted surfaces shrug off dust and other contaminates that could cause contact pitting.



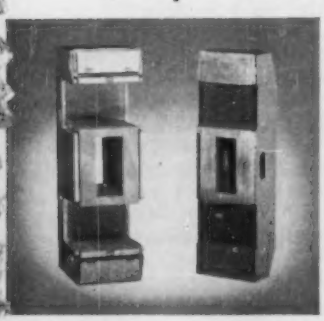
MAGNETIC STEEL ARC TRAP EXHAUSTS CONDUCTIVE GASES, REDUCES CONTACT EROSION. Size 2 starters feature arc trap which exhausts ionized gases, contains and quenches arcs. Arc trap splits and cools arcs quickly, reducing contact erosion, extending contact life.

STRONGBOX MOLDED COIL PROVIDES POSITIVE PROTECTION FOR COIL WINDINGS. Glass-filled alkyd resin protects coil to prevent flexing of windings, and resists dirt, oil, water, and mechanical damage.

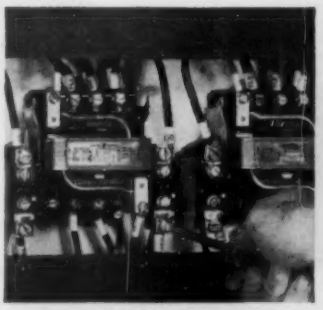


You get **MEASURABLE ADVANTAGES** with **GENERAL ELECTRIC CONTROL**

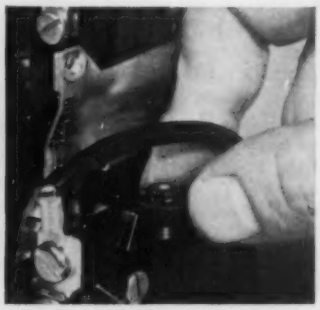
Only General Electric gives you all these proved features



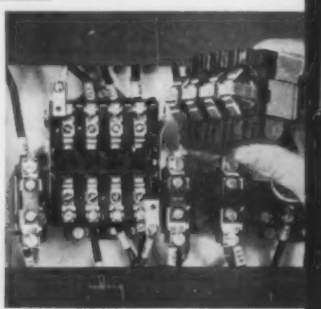
POSITIVE "MAKE," CLEAN DROP-OUT PROVIDED BY G-E MAGNET DESIGN. Any voltage sufficient to move magnet seats it firmly. Clean drop-out results from machined air-gap, short flux path.



STRAIGHT THROUGH WIRING ALLOWS QUICK, NEAT INSTALLATION. All line terminals are at top, all load terminals at bottom. This speeds installation, provides neater appearance. Pressure type terminals accept solid or stranded wire, ring or spade connectors.



BIMETALLIC OVERLOAD RELAYS ARE TRIP-FREE, ADJUSTABLE ±15%. Bimetallic relays standard on 100-Line starters, cannot be reset while overload exists. Handy knob allows ±15% adjustment of trip setting. Overloads can be reset manually or automatically.



FULL-FRONT ACCESSIBILITY ALLOWS EASIER INSPECTION, WIRING, MODIFICATION. No extra space needed—contact inspection, coil change, overload adjustment done from front.

CIRCLE 61 ON READER SERVICE CARD

when unlit. Suitable for computers, instruments and panels. **Color-Lite Div, Sloan Co, Sun Valley, Calif.**

Circle 319 on Reader Service Card

Lighted pushbutton . . .

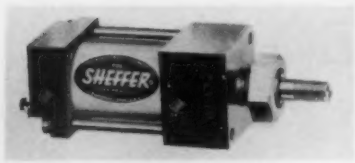
is DPDT switch with independent light circuit rated at 28 v dc or 115 v ac. Has nickel-plated brass plunger and anodized-aluminum case. Six lens colors are available. **Control Switch Div, Controls Company of America, Folcroft, Penna.**

Circle 320 on Reader Service Card

High-density polyethylene . . .

combines high resistance to environmental stress-cracking and thermal embrittlement with processing ease of conventional high-density grades. Available in 0.95 density with molecular weights of 50,000, 80,000 and 100,000. Stress-cracking resistance in 100,000-weight grade is 800 hr with anti-oxidant, 500 hr without anti-oxidant. Thermal-embrittlement resistance is 1000 hr with anti-oxidant and 700 hr without. Tensile strength at yield at 20 ipm is 3450 psi. **Goodrich-Gulf Chemicals Inc, East Ohio Bldg, Cleveland 14.**

Circle 321 on Reader Service Card



Stud-mount air cylinder . . .

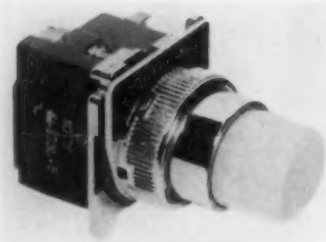
for 150-psi air, 250-psi hydraulic service, is a 1⅛-in. bore clamp type. Measures 1½-in. sq and has aluminum bar-stock heads for light weight. Sintered-bronze bushing in rod head is said to improve bearing surface, while head seals are retained-type flat gaskets to prevent extrusion. Priced at $6.95 for 1-in. stroke in either double-acting or spring-return models. From stock in 1-, 2- and 3-in. sizes. **Sheffer Corp, 326 W Wyoming Ave, Cincinnati 15.**

Circle 322 on Reader Service Card

Continuous booster power units . . .

give automatic oil intensification to 5000 psi. Available in 30- and 60-gal. reservoir capacities with constant or variable pump volumes to 32 gpm. Primary oil pressure is provided to 1000 psi, then automatically intensified to 3000 or 5000 psi, depending on booster ratio. Delivered as complete hydraulic power packages with 1800-rpm motor; valve and electrical circuitry; and choice of pressure-reversal switch or holding-cycle relay. **Hannifin Co, Dept 126, 501 S Wolf Rd, Des Plaines, Ill.**

Circle 323 on Reader Service Card



Illuminated pushbutton . . .

combines functions of pushbutton and indicating light. Has color-coded, molded-type transformer said to be immune to voltage-surge lamp damage. Operates with multiple-contact blocks or with any combination of NO or NC contacts. Plastic lenses come in red, blue, amber, green, clear and white. Available for 110-, 220-, 380-, 440- and 550-v applications. **Cutler-Hammer, 296 N 12th St, Milwaukee.**

Circle 324 on Reader Service Card

Magnetically latched solenoid valve . . .

can be actuated to either position in less than 15 millisec by single electrical pulse. Requires no "hold" current. Output rise time is 1 millisec, and leakage rate is stated at well under 1 cc per hr. Normally operates at pressures up to 500 psi, but can be used at up to 3500-psi pressure with minor modifications. **James, Pond & Clark Inc, 2181 E Foothill Blvd, Pasadena, Calif.**

Circle 325 on Reader Service Card

Compact vibratory feeder . . .

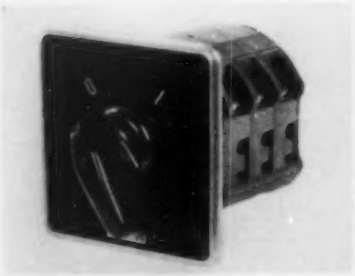
consists of 3-in. molded bowl, rheostat "on and off" switch and 5-ft power cord. Bowl handles disk-shape parts from smallest dia to ⅛-in. and cylindrical shapes up to ⅜ in. long. Measures 3½ x 5⅛ in. From stock. **VFC Div, Automation Devices Inc, Erie, Penna.**

Circle 326 on Reader Service Card

Leaded manganese-bronze alloy . . .

is 8% lighter than cast bearing bronzes, and offers 75,000-psi tensile strength. Available in extruded solid- and hollow-bar forms with close extruded tolerances. Can be forged. Suitable for bushings, bearings, gears, cams, connecting rods, valve stems, lead-screw nuts, etc. **Ampco Metal Inc, Box 2004, 1745 S 38th St, Milwaukee 1.**

Circle 327 on Reader Service Card



Protection switch . . .

for motors of 1 hp or less, has large rotary handle that moves through 90° to visually indicate overload, even from a distance. Eliminates need for pilot indicating-light. Trip-free from handle, switch cannot be held closed under harmful overload conditions. After overload tripping, switch automatically resets itself and is ready for immediate reclosing. Has built-in compensating device for ambient-temperature changes. Priced at $7 each. **Wood Industries Inc, 26 Central St, Ipswich, Mass.**

Circle 328 on Reader Service Card

Shaded-pole, split motors . . .

can be wound for 115-, 208- or 230-v operation at 50 or 60 c. Range from 35-w, 2-pole shaded-pole model rated at 3000 rpm and 1/150 hp at 115-v 60-c to 6-pole, permanent-split model rated at ¼ hp and 1075 rpm. Have centrifugally die-cast rotors and extra-large bearings. **Leece-Neville Co, 989 Athens St, Gainesville, Ga.**

Circle 329 on Reader Service Card

Alloy-aluminum wheels . . .

in 4, 5 or 6 in. dia, are available as either free-wheel or ¼-in.-keyway drive wheels. Have tapered roller bearings, tire grip, and cadmium-plated, heat-treated steel fas-

continued on page 66

"ALCOA ALUMINUM SCREW MACHINE STOCK ALLOY 2011 CUTS YOUR UNIT COST!"

Precision-made, high-volume screw machine parts cost less in aluminum

Final cost of your machined component . . . material cost plus production cost . . . is *lower* with Alcoa Alloy 2011-T3. That's because this faster machining alloy cuts production time . . . machines easier . . . can be held to close tolerances . . . gives a bright, clean finish. And Alcoa® Aluminum 2011-T3 gives you three times as many parts per pound as other, heavier metals, for still more savings. By using Alcoa Aluminum 2011-T3 Screw Machine Stock you get all the inherent advantages of automatic screw machine products.

Be sure to ask your Alcoa distributor or Alcoa sales office for your free *Alcoa Conversion Calculator*. It makes cost conversions from brass to aluminum quick, easy, finger-tip operations. Also get your free *Alcoa Screw Machine Stock Estimating and Operating Data Book*, the most comprehensive book of its kind in the screw machine field . . . packed with easy-to-find technical data.

You'll want information, too, on other Alcoa screw machine alloys: 2017-T4 or -T451 for strength at low cost, 2024-T4 or -T351 for strength with high production, and 6061-T6 or -T651 for superior finishes, excellent joining characteristics and extra corrosion resistance. Aluminum Company of America, 841-M Alcoa Building, Pittsburgh 19, Pa.

ADDITIONAL BONUSES YOU GET WITH EVERY ALCOA ALLOY:

1. Wide range of stock sizes for important price advantages.
2. Guaranteed market for up to 60 per cent of your Alcoa Aluminum turnings and borings.
3. Extensive mill and distributor inventories to meet all requirements.
4. Chamfered ends at no extra cost.
5. Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).

ALCOA ALUMINUM

SCREW MACHINE STOCK

CIRCLE 63 ON READER SERVICE CARD 63

the LEAD newsletter

Vol. 2 No. 5

Improved Sound Barriers Employing Lead

Whether you are concerned with a noisy office or a noisy machine, it is important to distinguish between materials that *stop* sound transmission and those which simply reduce sound reflection. A room finished in acoustic tile, for example, seems less noisy because sounds originating in it are not reflected back to a listener in the room. However, a noisy conversation or machinery noises will penetrate the acoustical tile and will leak out to adjoining rooms. To block this leakage, a sound barrier must have two key properties:

weight – the greater the weight (per sq. ft.) the greater the isolation or transmission loss.

limpness – A "limp" partition has a higher sound transmission loss than a stiff one of the same weight.

Lead approaches the ideal in the search for a heavy, limp material. Having a density two or three times that of common building materials (and 10 to 15 times that of wood), it is a "limp" material in the acoustical sense. This combination of properties makes lead desirable as a sound attenuator.

Comparative Weight Advantages

Because of the weight-limpness combination, a little lead will do the same job as a greater weight of other materials. This weight advantage can be of significance to the engineer. For example, while a cinder-block partition weighs 22 lb./sq. ft., 5½ lb./sq. ft. of lead will accomplish the same sound isolation task–with a resultant saving of 16½ lb. for every sq. ft. of partition, or 165 lb. for every linear foot if the ceiling height is 10 ft. This saving can mean lighter slabs and beams.

Cost Savings With Lead Partitions

Studies indicate many materials require 30 times the thickness of lead to accomplish equal sound inhibition. Thickness ratios are even more striking when lead is compared to a stiff, light material like wood. As an acoustical enclosure for machinery, 0.008 inch of lead is as effective as ¾ inch of fir plywood. By replacing a brick wall with ¼ in. lead sheets (allowing a 2 in. thickness for structural framing system for lead) useful floor space conserved, based on a cost of approximately $15 per sq. ft., represents a savings of about $7.50 per linear foot of partition.

Lead "Wallpaper"

If the weight of a wall can be increased without significantly increasing its stiffness, many existing problems of noise transmission can be remedied. With the addition of a layer of lead, as thin as ⅛ in. on each side, the weight of many typical partitions can be doubled, greatly raising acoustical isolation. Lead cloth, similar to leaded vinyls already in production, may be applied in a wallpaper-like fashion.

Lead improves the isolation properties of doors. Approximately 1/16 in. thick lead sheets with a decorated wood veneer laminated to one face of the sheet, and a pressure adhesive laminated to the opposite face, can easily be added to one or both faces of doors where high acoustic isolation is desired.

Machinery Enclosures

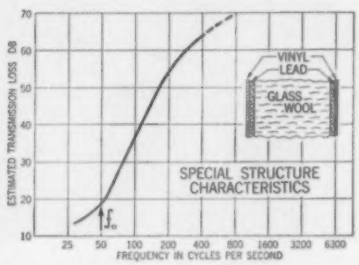
A leaded fabric and pressure sensitive adhesive, or lead foil with pressure sensitive adhesive, has application both in the fabrication of new machinery enclosures and in improving the acoustical properties of existing enclosures. It increases the weight of the enclosure and thus enhances sound transmission loss. And it provides a degree of vibration damping for the enclosure. Finally, because it will lap over joints in the enclosure, it seals airtight. A similar application is suggested for oil-cooled transformers in electrical substations within buildings. Pressure-sensitive lead tape applications might be found in the field of plastic phonograph and radio enclosures, as well as in commercial metal loud-speaker enclosures for installation in the ceilings of buildings.

Lead Backed Acoustic Tile

One of the major problems now facing manufacturers of acoustical tile is that the low weight and porosity of most effective sound absorbing materials permit the transmission of sound. The application of a very thin lead foil to the back of standard acoustical tile will prove effective as a sound damper and should permit the tile manufacturer to produce all of his various decorative patterned tiles without serious modifications.

Special Lead Structures

As an example of a structure of this type, consider the following theoretical five-layer lamination: vinyl film, ⅛" lead sheet, 3" of relatively low density Fiberglass or other resilient board, ⅛" lead and a final coat of vinyl. If the very high transmission losses, particularly at low frequencies, which are indicated by theory are realized in practice, a panel of this construction will have wide application in special areas such as jet engine test-cells, dynamometer cells, special audio-metric facilities and other types of research laboratories.



Versatile Material

Aside from its economical value as a reclaimer of expensive usable floor space (because of its thinness), lead has other notable advantages. It is tackable–it can be nailed, stapled and be cemented in place. It is paintable–lead sheet as supplied is ready for painting without any further surface preparation and it forms a durable bond with all conventional paints. It is fireproof. It is malleable–it folds or bends over any regular surface. It can be "dressed" over complex surfaces, and is easily cut and worked.

Informative Research Report Available

For more detailed information, a copy of *Improved Sound Barriers Employing Lead*, a report on the research study conducted by Bolt, Beranek and Newman, can be obtained by writing to: Lead Industries Association, 292 Madison Avenue, New York 17, N.Y. 2632

hoover quality

SELF-ALIGNING PILLOW BLOCK BEARINGS

LIGHT DUTY PILLOW BLOCK BEARINGS

ED Series meets requirements for quality made, economical units to carry light loads at normal speeds.

WITH *hoover-honed* RACEWAYS... *micro-velvet* BALLS

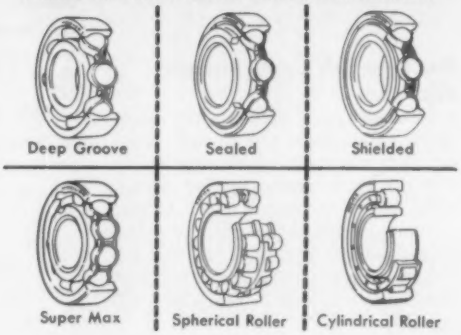
Hoover SP and SPH series pillow block bearings are designed for quick, easy installation. They are automatically self-aligning in any direction. The eccentric collar forms a self-tightening shaft lock. Elongated bolt holes in the base of the pillow block simplify mounting.

Hoover Quality bearing features assure long life and superior performance. *Hoover-Honed* raceways are super smooth, superbly finished. *Micro-Velvet* balls are accurate within millionths of an inch. Felt seals with metal shields retain factory applied lube and protect working surfaces from dirt.

Recommended for normal duty load conditions and shock, Hoover SP and SPH series pillow block bearings are available in shaft sizes from $\frac{3}{4}''$ to $2\frac{15}{16}''$.

Hoover-Honed and *Micro-Velvet* are Hoover Trademarks

HOOVER PRODUCES A COMPLETE LINE OF BALL AND ROLLER BEARINGS IN TYPES AND SIZES FOR MOST APPLICATIONS



hoover

BALL AND BEARING COMPANY

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Zone Sales Offices and Warehouses | 8581 South Chicago, Chicago 17, Illinois
290 Lodi Street, Hackensack, New Jersey
2020 South Figueroa, Los Angeles 7, California

Hoover Ball and Bearing Company PE-12
5400 South State Road, Ann Arbor, Michigan

Please send Bulletin 106 which describes Pillow Block Bearings.

Name_____

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teners. Said to be priced competitively with steel wheels. **Azusa Engineering Co Inc, 16208 Arrow Hghwy, Azusa, Calif.**

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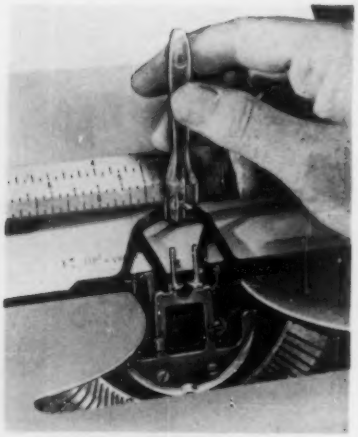


Technical symbols . . .

can be typed by bars individually fitted with plexiglass handles. Bar with desired symbol is slipped onto guide posts which can be installed by repair mechanic on either manual or electric typewriter. Type slide will print symbol when regular key is struck. Bar then can be removed and normal typing continued. Approximately 400 characters are available, including chemical, mathematical and grammatical symbols, Greek letters, subscript and superscript numbers, many in both pica and elite faces. Price is $4 for adapter; $3 for each symbol in its holder. **Mechanical Enterprises Inc, 3158 Jefferson Davis Hghwy, Arlington, Va.**

Circle 331 on Reader Service Card

Stack-switch experimental kits . . .

are used to make working switch samples during design stages and to make switching changes to meet specific requirements. Also suitable in assembling and servicing relays and remote control units. Available are three different kits containing contact springs and associated parts in ½- and ⅜-in. mounting centers. Priced at $9.90 each. **Switchcraft Inc, 5555 N Elston Ave, Chicago 30.**

Circle 332 on Reader Service Card

Drawing boards . . .

have aluminum edges for increased warp-resistance. Available in five sizes: 12 x 17 in.; 16 x 21 in.; 18 x 24 in.; 20 x 26 in.; and 23 x 31 in. **Anco Wood Specialties Inc, Glendale 27, NY.**

Circle 333 on Reader Service Card

DESIGN LITERATURE

Basic Human Factors for Engineers

PAUL A VERDIER. Exposition Press Inc, 386 Park Ave South, New York 16. 5¾ x 8¼, 108 pp. $4.

A book with this title should have been welcome and significant for all engineers concerned with the design of man-operated products. Because specialists in human factors engineering have already developed a wealth of data (*PE*—Sep 12, p 71)—in fact, the presentation of this data in forms more directly applicable by the equipment designer is a long-felt need.

Unfortunately this book can help to satisfy that need only limitedly, because it is concerned almost solely with measuring and comparing the ability of operators to perform already established tasks. This means that there is little here that can be applied to shaping and dimensioning a machine properly for human use—in fact, anthropometrics and biomechanics—two of the most significant contributions which human factors specialists have made to equipment design—are ignored. They are not even included in the author's listing of "basic human factors."

Mr Verdier's concept of task analysis may conceivably be of help to PRODUCT ENGINEERING readers.—JK

Electronics and Nucleonics Dictionary

N M COOKE, J MARKUS. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 6 x 9, 543 pp. $12.

This is a fully revised edition of a dictionary that for 15 years has been an authority on electronics terminology for engineers, technicians, students, technical writers, editors and secretaries. This volume covers nuclear science and technology along with the many new branches of electronics.

Effects of Sound on Heat-transfer Rates

PB 161724. Sprott, Holman, Durand. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ x 11, 26 pp. $1.

Experiments are described in which it was demonstrated experimentally that strong progressive sound fields may interact with a free convection boundary layer on a horizontal cylinder in such a manner as to produce increases in heat-transfer rates of the order of 100%. Shadowgraph flow-visualization studies indicate that the mechanism of the interaction is such that a separated flow region on the upper side of the cylinder is produced. No effect on the boundary layer or heat transfer is observed until the sound intensity is raised above a certain critical value. For the experiments described in the paper, the critical sound-pressure level ranged from 134 to 138 decibels.

In a qualitative analysis of the experimental results it is postulated that the increase in heat transfer is the result of an interaction of the phenomenon of acoustical streaming with the free convection boundary layer. It is also believed that the mechanism of thermoacoustic transduction may be applicable. Full title: "Experimental Study of the Interaction of Strong Sound Fields with Free Convection Boundary Layers."

Developing a Product Strategy

American Management Association Inc, 1515 Broadway, NY 36. 6¼ x 9½, 352 pp. $7.50.

This report defines the contributions of all levels of management to successful product development. Executives active in finance, research and engineering, production, marketing, and sales analyze various aspects. They discuss planning and organization, exploration, product screening, production, and many other areas. New sources of product ideas are examined and evaluated.

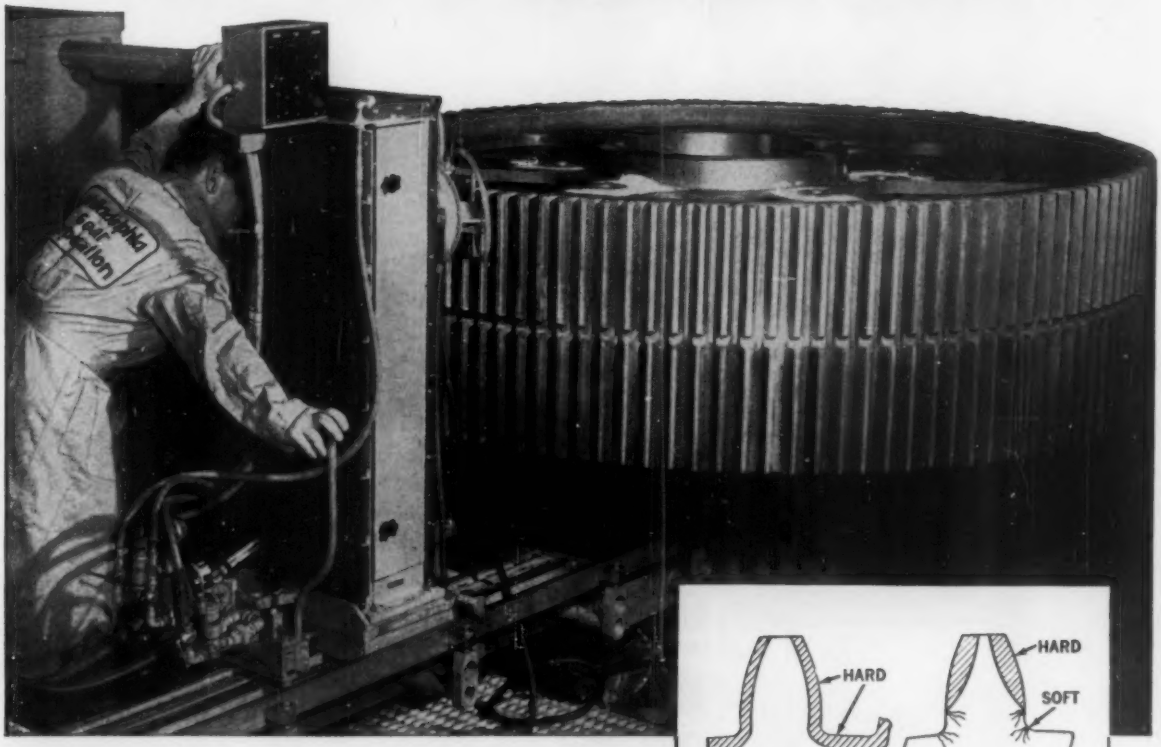
Patterns of Industrial Growth, 1938-1958

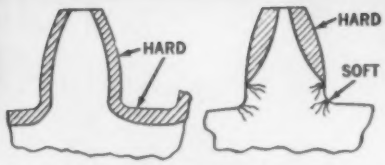
United Nations. Columbia University Press, 2960 Broadway, NY 27, 9¼ x 11¾, 471 pp. $8.50.

The dimensions and patterns of material growth over the twenty years, 1938-1958, in the industrial sector of the various countries of the world are measured and analysed in this publication for the first time. The distribution, according to areas of the world, stages of economic development and kinds of industry, of output

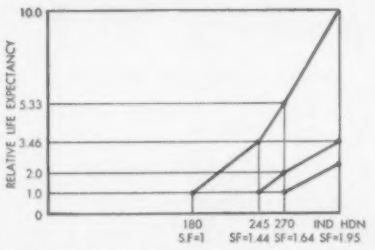
continued on page 71

New Philadelphia induction hardening increases life of large gear drives . . .





New Philadelphia full contour induction hardening (left) provides a continuous hardened area from one tooth flank around the root and up the other flank without interruption. There are no points of stress. Typical heat treated gear (right) shows inadequate hardening of root of tooth, a point of major stress.



This chart shows the relationship between load and gear life. Note that the improved service factor of a gear set may be used to substantially increase gear life, rather than to increase the load.

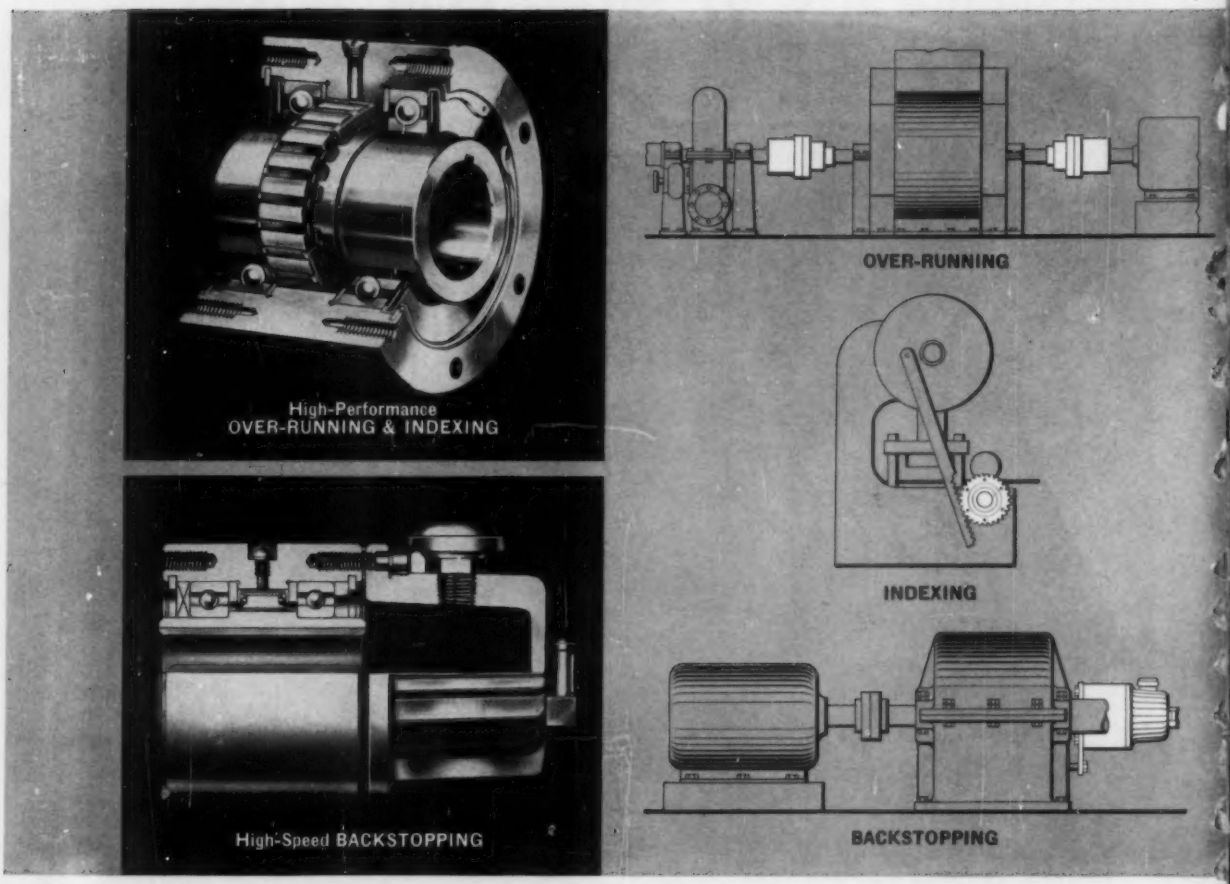
HERE'S WHY: Full tooth contour induction hardening of large gears provides a uniformly hardened surface from one tooth flank around the root and up the other flank without interruption. Eliminates points of thermal stress concentration. And there is no distortion, a problem of heat treated gearing that requires subsequent grinding.

This new, advanced Philadelphia method permits radical reduction in sizing and/or increased load carrying capacities. And it can easily harden even the largest spur, helical and herringbone gearing up to 180 inches in diameter, 20 inches in face, and 3/4DP.

Learn more about this new method for increasing the service life of your gear drives. Write for your copy of Bulletin 100.

phillie gear® / **PHILADELPHIA GEAR CORPORATION**
King of Prussia (Suburban Philadelphia), Pennsylvania

FORMSPRAG Clutches have



These Installations Prove Formsprag Has The Most Advanced Clutch Designs Available

On tough applications requiring high-performance over-running, indexing or backstopping, Formsprag clutches have *proved* their unusual durability, precision and reliability. Their long-life and minimum maintenance requirements, even under unusually demanding installation conditions, have provided many users with the answer to their clutch problems. Compare the following performance results on actual installations—Formsprag designs can help you, too!

High-Performance Over-Running

Application:
Forced and Induced Draft Fans.

Clutch and Mounting:
Model FO-732 Clutch-coupling (HPO-720 clutch with coupling) mounted on fan drives.

Requirements:
Continuous over-running at 1200 to 1800 R.P.M. (24 hours a day, 365 days a year).

Proved Results:
The Formsprag HPO clutch design with Formchrome sprags provides this company with greater durability and less maintenance than any other available clutch. Therefore, on all forced and induced draft fans, this manufacturer specifies Formsprag high-performance over-running clutches.

Precision Indexing

Application:
High Speed Press.

Clutch and Mounting:
Model HPI-700 feeding a progressive die.

Requirements:
20° indexing; feed is 700 strokes per minute; accuracy of feed must be within .005"; press operates 24 hours a day, 5 days a week.

Proved Results:
After poor service life and unreliable results from other clutch designs, a Formsprag high-performance indexing clutch was installed. Result—customers requirements for accuracy were met, clutch has had a life of 80 million cycles and is still running.

proved higher performance

(GREATER TORQUE & SPEED, HIGHER PRECISION, LONGER LIFE)

During the last two years, Formsprag has announced several major advances in over-running clutch design. These advanced concepts have been widely accepted by designers of modern power transmission systems. The high performance results they obtained on over-running, indexing and backstopping applications *prove* Formsprag clutches to have the most advanced designs available.

On-the-job records *prove* these high performance characteristics: (1) Formchrome sprags, with high-hardness and wear resistance, provide exceptional durability—no other manufacturer can offer the performance advantages of Formchrome sprags. (2) The improved sprag and retainer design of Formsprag High-Performance Over-running (HPO) and Indexing (HPI) clutches permit up to 30% higher operating speeds with same life span and up to 70% longer clutch life when operated at same RPM as ordinary clutches. (3) On backstopping applications, the High-Speed Backstopping (HSB) clutch design permits higher speeds, assures longer life and reduces maintenance to a minimum.

Specific case-history data on *proved* over-running, indexing and backstopping installations is provided below. In every instance, users of Formsprag High-Performance Clutches have found the answers to problems of wear, high-speed operation, precision and maintenance.

There is a Formsprag Clutch for every application. Standard models include: sleeve bearing, ball bearing, miniature, large-bore holdbacks, and high-performance types. For special applications, Formsprag engineers will recommend a modified standard clutch or design a special. Standard clutches are fully described in the Formsprag catalog—send for your free copy.

FORMSPRAG COMPANY

23607 Hoover Road, Dept. 114-A -- Warren (Detroit), Michigan

Representation Throughout The World • Precision Power Transmission Products

High-Speed Backstopping

Application:
Iron Mining (Taconite) Conveyor.

Clutch and Mounting:
Model HSB-700 clutch assembly mounted on high-speed shaft of reducer.

Requirements:
In abrasive atmosphere, clutch must over-run at 1200 to 1800 R.P.M. (24 hours a day, 9 months of year).

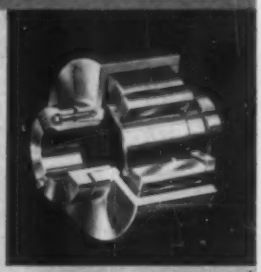
Proved Results:
On this rugged backstopping application, Formsprag HSB clutches solved problems of overheating, premature seal wear, and short clutch life. These high-speed backstopping clutches have been in operation for over a year and are still delivering their initial high performance.

OTHER FORMSPRAG PRECISION PRODUCTS

NEW RAWSON

CENTRIFUGAL CLUTCHES and CLUTCH-COUPLINGS

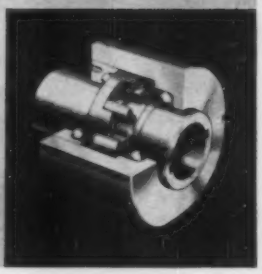
Used in a wide variety of applications, the Rawson design provides no-load starts for motors and cushioned starting of driven equipment. They permit using smaller motors and across-the-line starting.



REVLOK

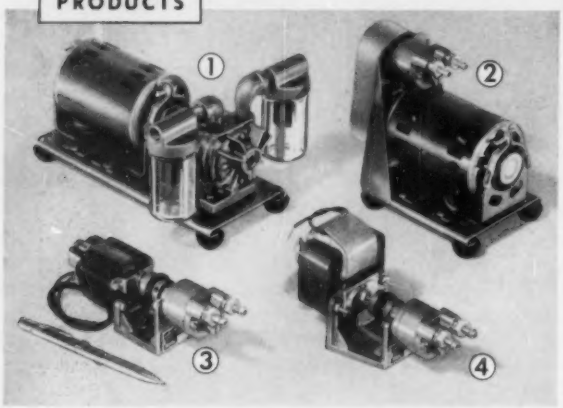
DUAL TORQUE-LOCKING and POSITIONING DEVICES

These multi-purpose devices stop feedback torque and provide two-directional positioning, over-running, backstopping and load-limiting. They can also be adapted for single revolution and torque-limiting functions.



ROTARY AIR
GAST
PRODUCTS

NEW for 1960



TWO TYPES OF MINIATURE OIL-LESS

GAST Rotary Vane VACUUM PUMPS and AIR COMPRESSORS

① Model 1030-V110-206 Vac. Pump, 1/20 h.p. Up to 1 c.f.m ; to 15" vac.

② Model 0330-V112-206 split phase 1/20 h.p. motor, .48 c.f.m. Up to 20" vac. or 15 p.s.i.g.

③ Model 0330-V102A-151 series wound motor. Up to .67 c.f.m. To 20" vac. or 10 p.s.i.g.

④ Model 0330-V110-202 shaded pole motor. Up to .35 c.f.m. To 20" vac. or 10 p.s.i.g.

⑤ (Below) Model 0630-P103 Compressor, up to .6 c.f.m. To 25 p.s.i.g. or 24" vac.

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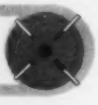

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and employment in 1938, 1948, 1953 and 1958 is also delineated. Significant changes in the structure of industrial activity and resources are also traced.

Other Books of Interest

Computer Abstracts

Monthly. Chancery House, Chancery Lane, London WC 2, England. 8½ x 11, $96 per year.

A monthly publication from England that will include more than 5000 references per year from some 800 publications and 8500 patents.

Crack-propagation Tests of High-strength Sheet Materials

PB 161355. Srawley, Beachem. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10, 16 pp. 50¢.

The fourth of a series on this subject, this fourth report shows how the results of this type of tests are modified by straining specimens at moderately elevated temperatures before testing at lower temperatures.

Directory of Members

American Machine Tool Distributors' Assn, 1500 Massachusetts Ave, NW, Washington 5, DC. 4 x 8¾, 258 pp. $2.

Proceedings of the Fifth Conference on Magnetism and Magnetic Materials

J A Osborn, Editor. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 7⅞ x 10½, 410 pp. $10.

Methods for Conducting Short-time Tensile, Creep, and Creep-rupture Tests Under Conditions of Rapid Heating

PB 151078. DMIC Report 121. Moon, Simmons, Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ x 11. $1.25.

Emulsifiable and Fire-resistant Rust Preventives

Van Y S Hong. PB 161352. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10, 68 pp. $2.

continued on page 72

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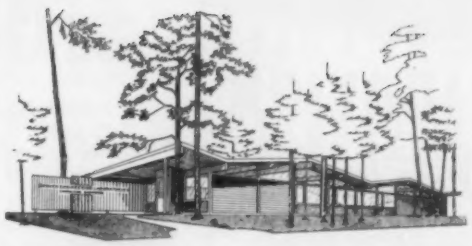

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☐ Bibliography: "Contaminants: Effects, Analysis, and Control." SAE Committee A-6.

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Final Report on Investigation of Dynamic Characteristics of Relays
Sandia Corp, Albuquerque, NM. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ x 10¾, 74 pp. $2.

Metal-cutting Bibliography, 1943-1956
American Society of Tool and Manufacturing Engineers, 10700 Puritan Ave, Detroit 38. 8¾ x 11¼, 1000 pp. $20.

Free and Inexpensive Educational Aids
T J Pepe. Dover Publications Inc, 180 Varick St, NY 14. 5¼ x 8, 289 pp. $1.35.
On the basis of objectivity, educational soundness and applicability to educational uses, 1500 free or inexpensive items (out of 7000 examined) are described.

Handbook of Chemistry and Physics, 42nd Edition
Chemical Rubber Co, 2310 Superior Ave, Cleveland 14. 5 x 7½, 3481 pp. $12.

Horsepower Ratings of American Standard Roller Chains
Association of Roller and Silent Chain Manufactures, PO Box 55247, Indianapolis 5. 8½ x 11, 11 pp. $1.

ABSTRACTS FROM THE LITERATURE

Analyzing Pneumatic Circuits

The general analysis of a pneumatic system is made without regard to the actual sequence of the components in the circuit. However, the flow factors are combined to provide the lowest maximum-flow conditions expected at the critical pressure loss. Other flow sequences through the same components may permit maximum flow rates up to ten percent higher than calculated. This is explained easiest with a graphical analysis of the system.

"Analyzing Pneumatic Circuits—It's an Art," C. Riske, Senior Engineer, Hannifin Company. National Conference on Industrial Hydraulics, Technology Center, Chicago 16.

Friction Between Sliding Surfaces

The present paper describes the results of studies which have been made of metallic contact, friction and surface damage between sliding, lubricated surfaces. The object of this investigation was fourfold: to develop a simple device for measuring both metallic contact and friction; to determine to what extent metallic contact actually occurs under these conditions; to find out what are the important factors influencing the degree of contact; to relate metallic contact, if possible, to friction and surface damage.

"Metallic Contact and Friction Between Sliding Surfaces," M. J. Furey, Esso Research and Engineering Co. American Society of Lubrication Engineers Paper No. 60 LC-10, 5 N Wabash Ave, Chicago 2.

Wear of Metals at 600 C

Apparatus is described for measuring friction and wear in controlled atmospheres. A comparison is made of the room-temperature behavior of copper, mild steel and brass, rubbed against a hardened tool steel, in four environments—vacuum, dry helium, dry carbon dioxide, and dry air. The effect of varying the water-vapor content in air is also discussed.

"Friction and Wear of Metals In Gases Up to 600 C," Cornelius, Roberts, United Kingdom Atomic Energy Authority. American Society of Lubrication Engineers Paper No. 60 LC-9, 5 N Wabash Ave, Chicago 2.

Vacuum-processing Terminology

Some 30 of the terms commonly used in vacuum technology are defined.

"Vacuum Words Are Important," American Vacuum Society. ISA Journal, Oct '60, 313 Sixth Ave, Pittsburgh 22.

Displaced Bearings

This paper is directed toward the apparently neglected possibility of displacing the lobe centers of two-lobe bearings orthogonally with respect to the mid-radius of the lobe. Analysis shows that when the lobe displacement is in a direction opposite to the shaft surface motion, and the

continued on page 74

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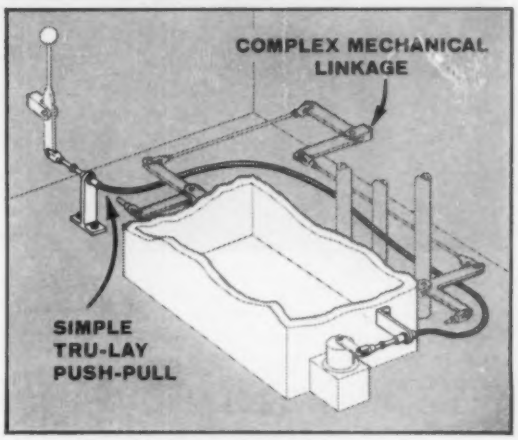

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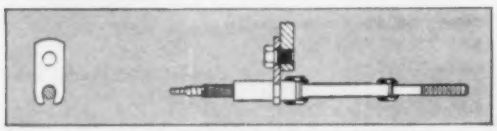

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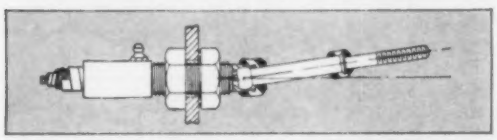

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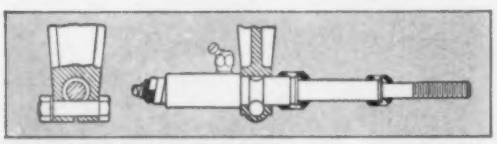

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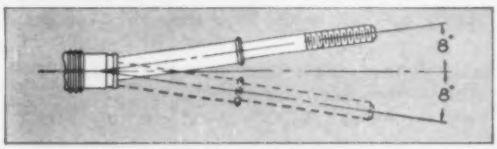

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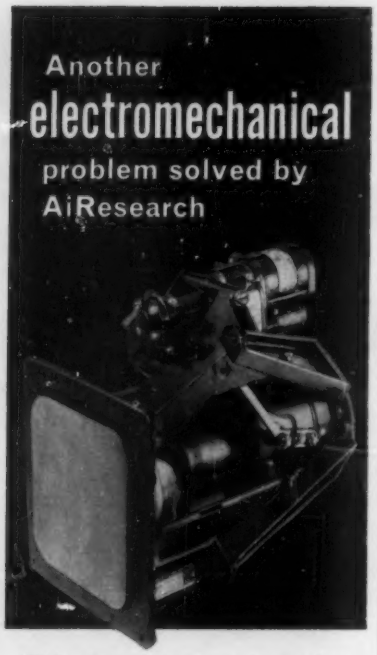

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"Orthogonally Displaced Bearings—1," D. F. Wilcock, General Electric Co. American Society of Lubrication Engineers Paper No. 60 LC-7, 5 N Wabash Ave, Chicago 2.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

SELECTING ADHESIVES—Bulletin 701, 19 pp. Contains tips on choosing proper adhesive, bonding techniques, testing methods; and glossary of adhesive terms. Tabulates adhesive characteristics and causes and remedies for bond failures. Adhesives Dept, Raybestos-Manhattan Inc, PO Box 1021, Bridgeport 2, Conn.

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STANDOFF FASTENERS—Booklet, 18 pp. Discusses advantages and disadvantages of various designs and materials; installation costs and how to reduce them; cost of unnecessary rework; how to select fasteners; weight saving; causes of failure, etc. Western Sky Industries, 21301 Cloud Way, Hayward, Calif.

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TUBING WEIGHTS—Brochure, 14 pp. Tabulates dimensions and weight per ft for round mechanical tubing up to 10 in. sq; rectangular and pressure tubing up to 5 in.; and 20 pipe sizes. Electricweld Tube Div, Jones & Laughlin Steel Corp, 3 Gateway Center, Pittsburgh.

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PRECISION BEARINGS—Catalog 60, 24 pp. Contains dimensions and drawings of 21 commercial and precision pillow blocks, flange, takeup- and jack-shaft units. Recommends load ratings for each series. Roberts Mfg Inc, Salina, Kan.

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SOLENOIDS—Catalog, 86 pp. Provides dimensional drawings and specifications for general-purpose; long- and short-stroke; heavy-duty, high-speed; reversing; explosionproof and push and pull types. Discusses conversion of ac solenoids to dc operation and fundamental brake properties. Includes price lists. Trombetta Solenoid Corp, 329 N Milwaukee St, Milwaukee.

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INFRARED PHOTOELECTRIC CONTROL—Bulletin 1B-2, 8 pp. Illustrates and gives specifications for 12 general-purpose, long-range and tele-optic long-range models. Typical materials-handling, counting, inspection and control installations are pictured and discussed. Cramer Controls Corp, Electronics Div, Centerbrook, Conn.

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LIMIT SWITCHES—Bulletin B-30, 4 pp. Contains force and movement data, electrical ratings and dimensional drawings of 10 heavy-duty and 12 general-purpose, metal-enclosed types. Unimax Switch Div, W L Maxson Corp, Ives Rd, Wallingford, Conn.

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METAL SPINNING AND FABRICATING—Brochure, 8 pp. Discusses metal-spinning advances and tabulates normal spinning tolerances and process capacities. Sketches show use of breakdown chuck; spinning from a welded cone; and steps in spinning a cone, hemisphere and cylinder. C W Torngren Co Inc, Sommerville, Mass.

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FLUID-POWER VALVES—Bulletin 100-P16, 4 pp. Outlines performance and dimensional data of two 2000-psi models. Porting-spool actions in inlet, outlet and working sections are reviewed. Commercial Shearing & Stamping Co, 1775 Logan Ave, Youngstown.

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TEFLON HOSE ASSEMBLIES—Bulletin TC-46, 4 pp. Covers properties, specifications and illustrated instructions for assembling general-purpose hose and reusable fittings. Anaconda Metal Hose Div, Anaconda American Brass Co, PO Box 791, Waterbury 20, Conn.

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SWITCHBOARD INSTRUMENTS—Bulletin GEZ-3109, 4 pp. Spells out design features, specifications and electrical ratings of ac voltmeters and ammeters

continued on page 77

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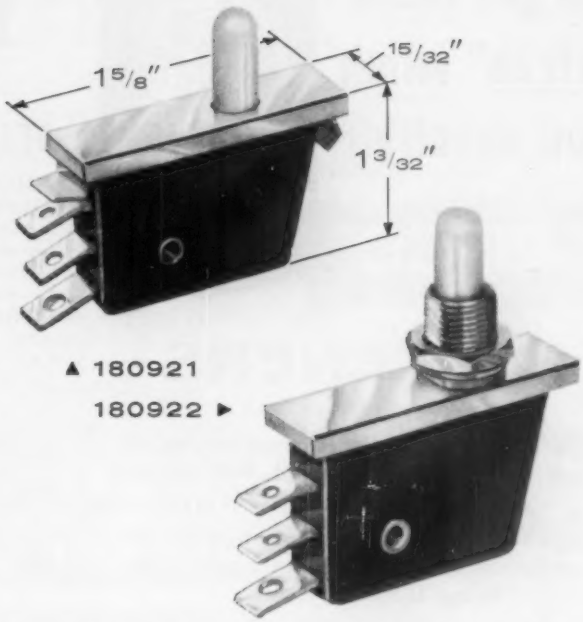

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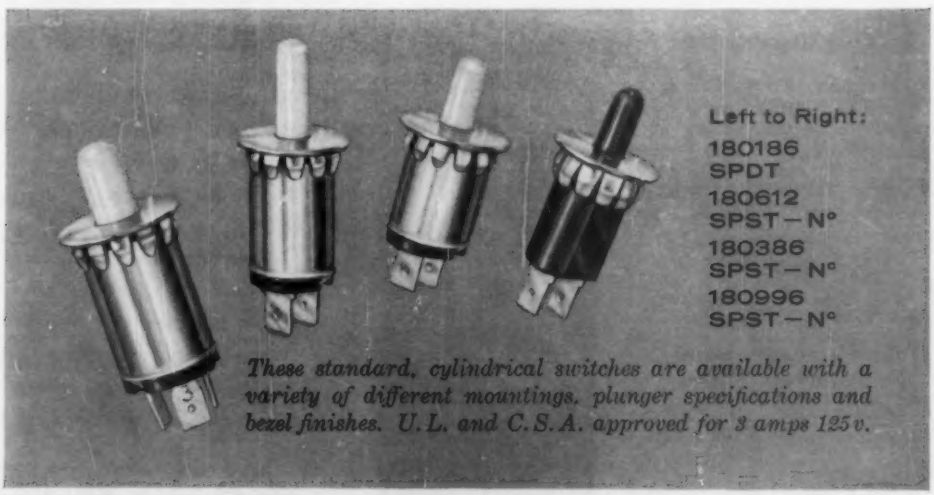

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with 180° scales. Includes dimensional drawings and external connection diagrams. General Electric Co, Schenectady 5.

Circle 360 on Reader Service Card

WELDED PADS AND BOSSES—Study report, 4 pp. Offers tips on economically adding pads and bosses to steel weldments. Design dos and don'ts are sketched. Lincoln Electric Co, Box 3115, Cleveland 17.

Circle 361 on Reader Service Card

HIGH-ACCURACY VOLTMETER—Bulletin GE2-3254, 2 pp. Describes operation and application of expanded-scale model. Contains dimensional drawing, along with specification and price lists. General Electric Co, Schenectady 5.

Circle 362 on Reader Service Card

LIQUID-LEVEL SENSOR—Folder, 4 pp. Gives specifications and describes how combination ultrasonic probe and transistor-equipped control can monitor large number of liquids. Acoustica Associates Inc, Gauge & Control Marketing Dept, 10400 Aviation Blvd, Los Angeles 54.

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DC ELECTRIC TIMING MOTOR—Folder, 4 pp. Details construction and operating advantages of permanent-magnet-type unit. Illustrates dimensions and lists ratings and availability of components. Haydon Div, General Time Corp, 245 E Elm St, Torrington, Conn.

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DIE-STAMPED CIRCUITS—Booklet D1, 12 pp. Compares properties and performance of die-stamped circuits with etched printed circuits. Gives hints for circuit design, including layout, artwork, and current-carrying capacity, and lists standard tolerances for fabricating die-stamped circuits. Dytronics Inc, 115 Main St, Rochester, Mich.

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SERVOMOTORS—Catalog, 24 pp. Contains electrical and mechanical specifications, outline drawings and torque–speed curves of sixteen size-8 and size-11 servomotors. Discusses ways to achieve damping, including rate-feedback and velocity-damping, and shows development of pertinent transfer-function equations. Helipot Div, Beckman Instruments Inc, Fullerton, Calif.

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FLAME-PLATED COATINGS—Bulletins F-1246-A, F-9889-B, F-1435 and F-1436, 9 pp. Former lists compositions and physical constants of six metal-parts coatings. Others detail physical and chemical properties and applications for three tungsten carbide–cobalt coatings. Linde Co, Div Union Carbide Corp, 270 Park Ave, New York 17.

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SYNCHRO-CONTROL TRANSFORMERS—Data sheets, 8 pp. Traces electrical and mechanical characteristics and performance at temperature extremes by 17 models. Includes phasing and dimensional drawings. John Oster Mfg Co, Avionic Div, Racine, Wis.

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MINIATURE PUSHBUTTON LIGHTS—Bulletin 69, 2 pp. Contains dimension diagrams and optional electrical-connection arrangements for mormally open and normally closed combination indicator lights and pushbutton switches. Lists specifications for eight incandescent and three neon-type lamps. Transistor Electronics Corp, 3357 Republic Ave, Minneapolis 26.

Circle 369 on Reader Service Card

ELEVATED-TEMPERATURE LOCKNUT—Bulletin 2686, 4 pp. Compares physical properties of 800-F nut with aircraft-and missile-industry standards. Lists sizes and interchangeability with other nuts by NAS and AN numbers. Standard Pressed Steel Co, Box 545, Jenkintown, Penna.

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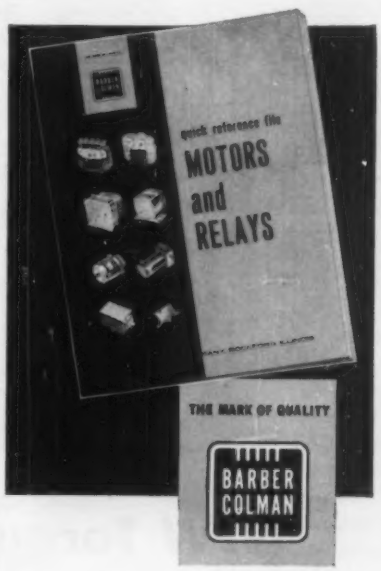

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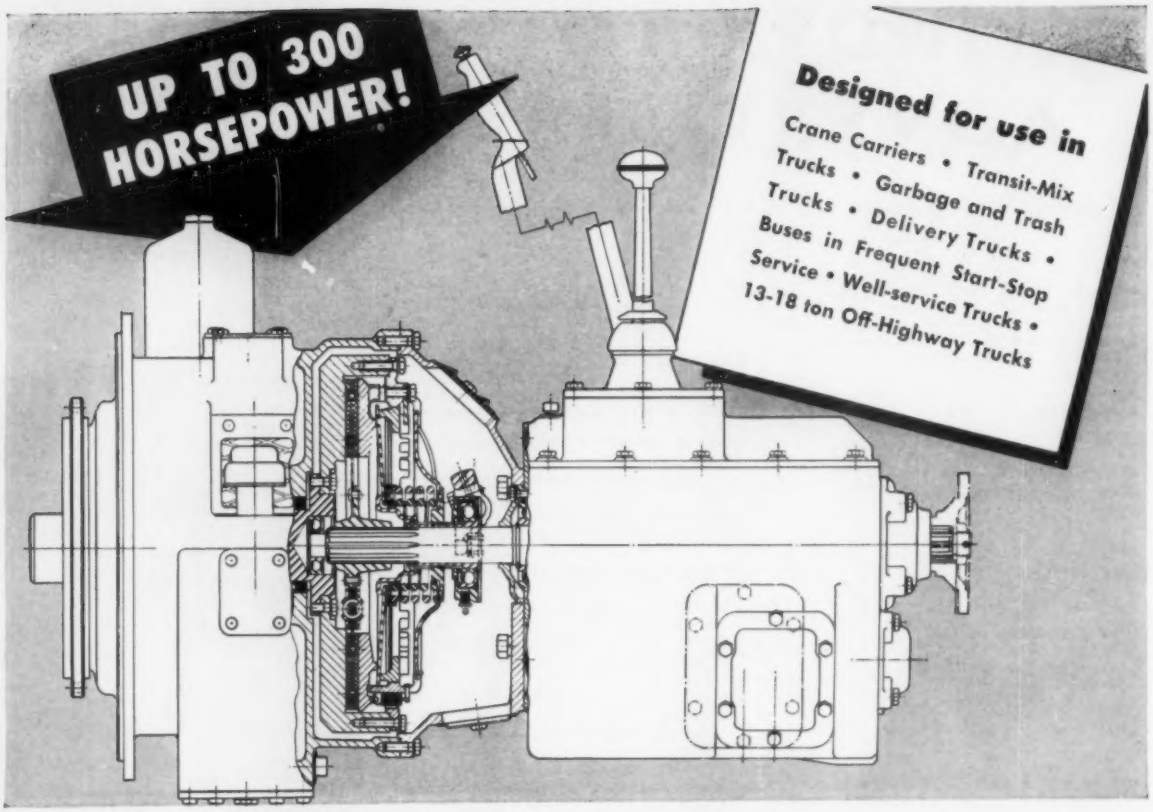
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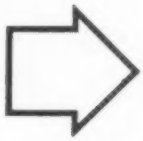

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18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P50 P51 P52 P53 P54 P56 P58 P59 P60 P61 P62
P64 P65 P66 P67 P68 P69 P70 P71 P72 P73 P74

*MULTIPLE Key No.	PRODUCT ADS Specific Product

(please print or type) *If this is change of address, check box* ☐

Name ..... Title .....

Street .....

City ..... Zone ..... State .....

Company ..... Major Product Manufactured .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
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P50 P51 P52 P53 P54 P56 P58 P59 P60 P61 P62
P64 P65 P66 P67 P68 P69 P70 P71 P72 P73 P74

*MULTIPLE Key No.	PRODUCT ADS Specific Product

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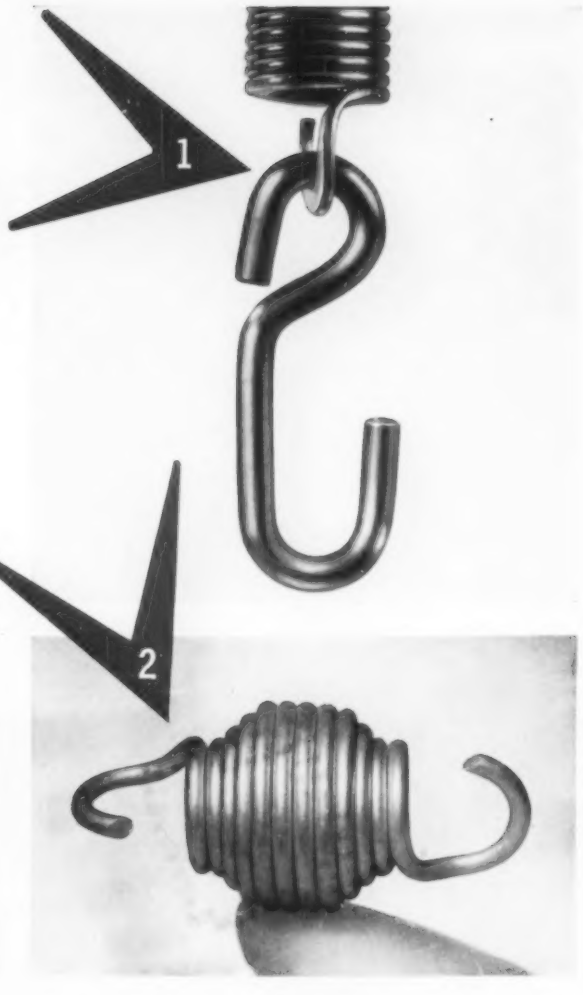
Why it pays to look at the end in the beginning



1. In this pick-arm spring for a textile machine, natural frequency vibration plus rigid end restraint caused early failure. By redesigning spring and adding swivel hook to end assembly, failure was avoided and cost reduced as well.

2. Fatigue failure caused by bending stresses occurs where end hooks join working coils. In this method of reducing the combined stress, two coils at each end are wound with a reduced diameter.

3. Another method for reducing stress concentration where end hooks join coils is to thread a flat stamping into end coils.

Here are a few examples of why it pays to call on the springmaker early in your design problems. End-hook failure of extension springs is a common occurrence that experience can help avoid. Check your specifications for performance and production economy by consulting an A.S.C. spring engineer. Write for bulletin "How to Solve Your Spring Design Problems."

5903

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Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
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Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
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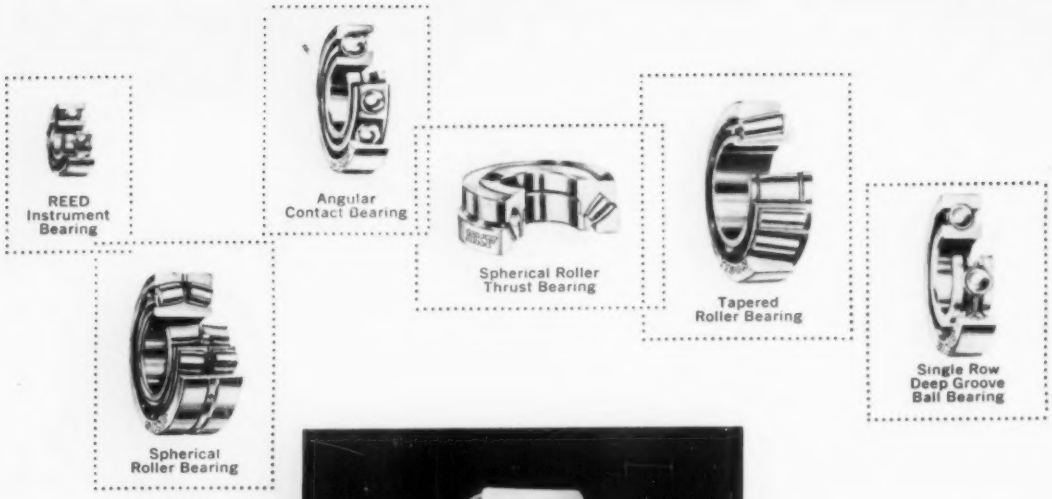

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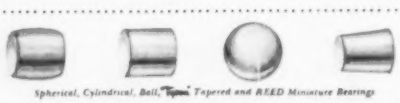
So, before you specify a "special size" bearing, call the nearest SKF sales office first. The odds are better than 1,000 to 1 that there's already a standard SKF bearing of exactly the size you need. 6007



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